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Contents

Editorial

HOW MAY DOCTORS HELP MOST IN CONTROLLING PULMONARY DISEASE?

CONVINCING evidence has been presented by the contributors to this Symposium that many patients suffering from serious pulmonary disease may receive great benefits from surgical treatment. Safe surgical exploration of the thoracic cavity has permitted a correlation of clinical and pathological findings during life which have clarified many issues at stake. A more direct attack upon pulmonary disease is now possible. Drastic reduction in mortality rates for elective surgery of the chest wall, lungs, esophagus and even heart have been effected. Periods of postoperative disability can now be foretold with reasonable certainty. The degree to which health will be restored can be predicted with greater accuracy.

Although the past decade has seen distinctive and practical contributions in the field of thoracic surgery, there is reason to believe that in the near future success in handling certain pulmonary diseases will be even more noteworthy. Improvements all along the line may be expected. Perfection of technical phases, which are the immediate concern of the surgical team, will continue. However, it will be impossible to show in the future the same accelerated reduction in operative mortality and morbidity that has occurred within the past few years. For example, the mortality in partial resection of the lung has been dropped from over 20 to under 5 per cent, and in total pneumonectomy from 50 to under 10 per cent. It is therefore obvious that any great increase in the effectiveness in handling certain pulmonary diseases cannot be attributed, except in small degree, to a possible further shrinkage of the risk of operation.

The great impetus to effective handling of thoracic disease will come from the other end of the line. The profession at large, upon whom rests the responsibility for the apprehension of disease, should so improve upon the timing of their diagnostic work that therapeutic efforts will be directed to a far greater proportion of favorable lesions.

The discovery of pulmonary disease during its incipiency is a fertile field that has not been well cultivated; in fact, the profession can almost be accused of negligence. For example, let us consider two of the most important pulmonary diseases, tuberculosis and cancer. The former ranks as the number one cause of death in adolescence and early adult life, and it ranks first in economic loss. The second ranks near the top of the list of cancers which cause death, and it has become one of the most impor-

tant of all pulmonary diseases as emphasized by Blades and Overholt in this Symposium. It is appalling that the score on early discovery of tuberculosis is not greater than 20 per cent, as indicated by reports on sanatoria admissions in this country. The score on the discovery of curable pulmonary malignancy is also appallingly low—in the neighborhood of 15 per cent. By waiting to let the lesion in either case progress to the point where the doctor is certain that the patient needs an x-ray, thereby justifying the expense of such an examination, we simply make it difficult or impossible to obtain satisfactory results from treatment. By a simple reversal of the ratio of minimal (20 per cent) to advanced lesions (80 per cent) which come up for treatment, the whole picture in tuberculosis would change overnight. We would then promise 95 per cent good results on 80 per cent of the whole rather than limiting the high batting average to a minority group and then struggle to obtain doubtful results with the major proportion of the tuberculous population. The same applies to primary malignancy of the lung. If the majority of the lesions were uncovered in their pre-symptom or early symptom stage, the profession could boast of the highest cure rate for any internal cancer.

This is not wishful thinking as we know there is within our reach a method of bringing many pulmonary lesions to light in their early stages. This statement is true irrespective of the fact that in the case of either disease there may be no early symptom or no abnormal physical sign. It is true regardless of the fact that when symptoms and signs do appear they may be considered inconsequential, variable or unreliable. The one action the medical profession can take which will double or treble the number of early diagnoses made in chest disease is to see that all patients who come to them for any advice have a single roentgenogram of the chest at least once a year.

Doctors must all be made to realize that no matter how carefully or painstakingly the physical examination of the chest is done, absence of abnormal palpatory findings, percussion sounds or ausculatory sounds do not spell freedom from disease. Neither does absence of symptoms mean that there is no latent disease. A negative physical examination without a negative chest film gives no assurance that the patient will not be dead next year of tuberculosis or pulmonary cancer. The profession has long recommended to the public that they get in the habit of submitting to an annual physical examination including urinalysis, blood counts, and Wassermann test. To this should be added a single film of the chest. Hospitals should routinely x-ray all patients on admission.

Tuberculosis workers have long been convinced of the fact that if this communicable disease is ever to be controlled the population generally will have to be screened if all unsuspected cases are tracked down. Sanatoria staffs are reaching out as far as they can but their coverage is wholly inadequate. The United States Public Health Service might take over and the State carry out compulsory isolation of all positive sputum cases. Most physicians would resent such a socialized step. A practical solution can be worked out with a co-ordinated effort of existing agencies with practicing physicians and hospitals taking over the responsibility of patients under their care.

Expense has been the chief obstacle to the inclusion of chest roentgenography as a part of a physical examination. A search is well under way to perfect accurate and inexpensive ways to produce chest x-rays wholesale. Sensitized paper is available at about one-half the cost of the full-sized celluloid films and is almost as accurate. A method of recording the fluoroscopic image on a 35 mm. film has also been developed. Potter[1] working in collaboration with the General Electric Corporation Laboratories has developed a unit for taking a 4 by 5 inch film. This method has been found by Douglas and Birkelo[2] to be

reasonably accurate showing an error of but 2.7 per cent. Special equipment for miniature chest roentgenography may eventually be available in large x-ray offices and hospitals. For the moment, the initial cost of special equipment will probably limit the number of units which will find their way into general use.

For the time being, doctors must rely on existing x-ray facilities. Increasing use should be made of out-patient departments of city, county and state sanatoria for patients who cannot afford to pay costs. Doctors in private practice should make arrangements with roentgenologists and hospitals so that their patients may be referred for a routine chest film at a cost adjusted to make the service possible. Charges of \$5.00 to \$15.00 for an x-ray examination of the chest are prohibitive for a routine service. These prevailing fee schedules have been based upon a more time-consuming examination which includes fluoroscopy and frequently stero films. In routine work the patients are handled entirely by technicians so that the actual cost of taking and developing each film is not great. Roentgenologists can read

from seventy-five to one hundred twenty-five routine films an hour. From a practical standpoint, therefore, it would seem entirely possible to bring the cost of routine single chest films within the reach of all private patients of any doctor.

It is within our power to discover pulmonary disease in many patients well in advance of the time that it becomes life threatening. Action must be taken before symptoms become so alarming that the issue is forced. By virtue of the fact that the lung lends itself so well to x-ray scrutiny, doctors are in a position to give real protection to their patients as far as serious pulmonary disease is concerned. The finishing touches can be put on the program to eradicate tuberculosis, and while this is being done many patients who harbor unsuspected malignancy may be saved from a certain death.

RICHARD H. OVERHOLT, M.D.

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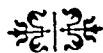
Original Articles

ANESTHETIC PROCEDURES IN THORACIC SURGERY

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INTRODUCTION

ANESTHESIA for thoracic surgery has been one of the prime factors in converting the hitherto formidable procedures of this branch of surgery into safe, helpful and curative measures. Vast strides have been made in the past ten to fifteen years in thoracic surgery during which we have witnessed the development of operations for pulmonary tuberculosis, and in the past eight years, removal of the whole lung for extensive bronchiectasis or tumor. In anesthesia we have seen the introduction of the endotracheal tube for the control of respirations, positive pressure and suction drainage of mucus, pus and blood. The carbon dioxide absorption technic has permitted the anesthetist to administer anesthetics with a minimum loss of body heat, less disturbance to the O_2-C°-2 ratio and has enabled him to employ the newest gas, cyclopropane, with the highest possible oxygen concentration and safety to the patient. Oxygen analysis of the blood from the pulmonary artery and vein and from the aorta have shown saturation of 95 to 100 per cent[1] under cyclopropane anesthesia. During spasm, however, the oxygen saturation dropped to 70 per cent. It has been argued in the past that thoracic surgery did not progress due to lack of these essentials in anesthesia.

We find a diversity of opinion among our leading chest clinics as to the type and anesthetics employed. Is it any wonder when one considers the short span of time covering the developments of thoracic surgery? The anesthetists and surgeons of England, Australia, Canada, Sweden, Germany and this country have been pioneering in a field of anesthesia. Only by contributions from the trials and errors of these pioneers has the present status of anesthesia in these difficult surgical procedures been developed. It is our purpose to state our experiences in over 2,000 thoracic operations of all types, describing the technics which we have found safe and which have permitted our surgeons to operate unhampered by the bug-a-boo of stormy induction, uncontrolled anoxemia, the overflowing airway and prolonged depression of reflexes.

The requirements of an ideal anesthetic for thoracic surgery have been clearly outlined by Eversole and[2] Overholt. In their experience cyclopropane fills this necessity. Beecher[3] states that ether, with nitrous oxide induction is the agent of choice in thoracic surgery because it is well tolerated by the circulation and does not depress the respirations and is nontoxic to vital tissues. Barbour,[4] Bourne,[5] and Stehle[6] find ether causes increase in blood concentration and production of acidotic states. Bourne rec-

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ommends cyclopropane-oxygen or spinal anesthesia in these handicapped patients.

In this series are included anesthesia for the various stages of thoracoplasty, extrapleural pneumothorax, internal pneumolysis, pneumonectomy, lobectomy, abscess of the lung, empyema, diaphragmatic hernia and surgery of the heart.

The patients, as a result of their pathological processes, present varying pictures of altered physical states.

The more common factors that make these patients different from other surgical patients are lowered vital capacity and vital reserve, excessive secretions of the respiratory tract, secondary anemia and sepsis. Due to their disease there is a reduction of available absorptive surface of the lungs which limits the absorption of both the anesthetic and oxygen.

Some of the complications that are created by the operation, and which make anesthesia for these cases difficult, are, rib stripping, open pleura, paradoxical breathing, stimulation of the mediastinum, traction on the lung causing vagovagal reflexes which create cough, respiratory spasm and obstruction, arrhythmias of heart and respiration; in lobectomies excessive secretion, pus, and blood and lung detritus, and posture of the patient on the operating table. In operations on the lung it is often necessary to have the patient lie on the healthy side, thus it is partially immobilized in the dependent position which limits its excursion as well as that of the diaphragm on the same side. This condition is aggravated further by the front and rear braces which hold the patient in position and the elevation of the bar or pillow which is used to widen the intercostal spaces of the operable side of the chest.

The ideal anesthetic should be: nontoxic to vital tissues, nonirritating to the respiratory tract, rapid acting for induction to eliminate stimulation of secretory reflexes and excitement, controllable for maintenance of anesthesia, with low concentration to ensure complete oxygenation, quiet respirations and prevent anoxemia. It should be a rapidly reversible anesthetic that will allow the patient to return to cough reflex and swallowing as soon as the operation is finished.

A sufficient airway should be provided with nasal tubes, oral airway, intratracheal catheter. The carbon dioxide filtration method should be employed with facilities for positive pressure and suction of secretions.

Patients are prepared with adequate bed rest, special diets and treatments. Blood examinations, vital capacity estimates, and selection of patients for surgery are done at conferences between internist and surgeon.

Many of the patients, especially those with tuberculosis and bronchiectasis, have excessive infectious secretions, very often with cavity formation. Postural drainage has aided greatly in the management of these patients. This procedure is carried out in the morning of operation. If the patient is known to have a large amount of secretion and is unable to evacuate it himself, bronchoscopy is performed preoperatively.

The ideal time of the day for chest operations is in the afternoon, so that postural drainage may be adequately carried out before hand. By so doing, it has not been necessary during the past five years to do intratracheal intubation on any thorocoplasty. To obtain sufficient drainage during operation, the operating table is placed in ten degrees Trendelenburg position before the anesthesia is started. In only a few cases has any secretion been found in the face piece after operation.

The proper posture of the patient on the operating table is one of the important factors which determines the smooth running of the operation and the anesthesia. For the surgeon it means speed of operating, good hemostasis, proper exposure of the field of operation, and the elimination of the discomforts, the presence of which leads to fatigue and oftentimes loss of equilibrium. With good posture of the patient during operation, respirations are not impeded to any great extent, with the

result that the patient is kept in a state of physiological oxygenation. Also, the control of any abnormal secretion is better facilitated.

MAINTENANCE OF AN ADEQUATE AIRWAY

Before discussion of the methods of anesthesia for thoracic operations, technics for the preservation of the air passages during anesthesia with intratracheal catheter, nasal tube, oral airway, suction of secretions from the respiratory tract and application of positive pressure will be considered.

Intratracheal intubation is used in the operations for pneumonectomy and lobectomy for four reasons: (1) to insure a patent airway for exchange of the anesthetic mixture, (2) to provide pressure when it is needed, (3) to afford an unimpeded avenue for the emergency application of Guedel's artificial respiration or controlled breathing with oxygen during apnea, and (4) to offer passage for the suction of pus and blood from the respiratory tract during operation. Whenever the intratracheal catheter is used a Water's balloon cuff is always placed one inch from its tip and inflated with 5 cc. of air after intubation. This is to insure a tightly closed system and prevent gaseous exchange around the intratracheal catheter in the trachea. No complicating infection or damage and no accident from the balloon has been noted, except that occasionally a balloon will collapse from a leak in its wall. If the balloon fails to function, a vasalined bandage is packed into the mouth about the intratracheal tube. A rolled bandage makes a convenient prop to prevent closure of the teeth on the intratracheal tube. The intratracheal intubation is carried out by one of two methods: For tumor of the lung or nonsecretive cases, the patient is induced with cyclopropane-oxygen, with or without a small amount of ether to obtain complete glottic relaxation before the intratracheal tube is introduced. In cases of cavity formation or excessive secretion as bron-

chiectasis, the pyroform fossae, glottis, and trachea are ansethetized with larocaine or cocaine 4 per cent and 5 cc. of 2½ per cent solution is injected into the trachea with a curved tube introducer. In fifteen minutes the intratracheal tube is inserted with an Everscope or Guedel Laryngoscope. The ease with which the tube can be introduced under local anesthesia has led to its use more and more, even in cases without secretion. During the past five years, this method has been employed almost universally. The type of catheter preferred is the silk woven, or Magill, No. 34 for women and No. 38 for men. For aspiration of secretions during operation No. 16 to 20 French catheter is passed through the intratracheal tube.

The gas machine is then connected to the intratracheal tube by means of an adapter which is inserted into the face piece holder of the rebreathing tubes and induction with cyclopropane-oxygen is performed with carbon dioxide filtration technic. Very rarely a severe spasm of the bronchi may ensue which is overcome with rhythmical positive pressure on the rebreathing bag with a very high oxygen concentration of the cyclopropane-oxygen mixture.

If the intratracheal tube is not considered necessary or contraindicated, rubber nasal tubes are used in each nostril. These are inserted as soon as the nasopharyngeal reflex is sufficiently depressed and they are retained for the duration of the operation. These tubes not only prevent pharyngeal spasm but afford an avenue of drainage for any secretion from the respiratory tract or mouth. These airways are left in place until the reflexes of the nose and throat are established in order to prevent the possibility of masseter spasm resulting in aspiration of vomitus or secretion. Also, postoperatively, they tend to stimulate nasopharyngeal and cough reflexes which aid in expelling any retained secretions in the respiratory tract and aid in stimulating the patient to a conscious state and normal control of reflexes.

POSTOPERATIVE INTRATRACHEAL SUCTION

Intratracheal suction is performed routinely immediately postoperatively by passing a No. 24 French catheter through the nose. By stimulating the glottis a cough reflex is instituted; this act opens the glottis and the catheter is passed into the trachea. If this fails, bronchoscopic suction is carried out in cases with retained secretions.

POSITIVE PRESSURE

Positive pressure is very simply performed by manual pressure on the rebreathing bag of the gas machine provided all joints of the closed system are tight. This pressure should not exceed 20 mm. of mercury pressure. The safest measure to individualize[3] positive pressure is by the direct observation of the lung by the anesthetist or surgeon to insure against over-inflation. When one thoracic cavity is opened, there is no real need of positive pressure until the surgeon wishes to re-inflate the lung just before closing the thoracic cavity. But if both thoracic cavities are opened intentionally or accidently, positive pressure becomes a vital necessity.

ANESTHESIA TECHNIC

Preliminary Medication. When cyclopropane-oxygen is used solely as in empyema operations, or in combination with regional novocaine anesthesia, atropine is substituted for scopolamine as it has more depressing action on the secretory glands than the vagal reflexes of respiration and circulation. The average dosages of the drugs used for preliminary medication are nembutal gr. 3, two hours before operation and morphia gr. $\frac{1}{6}$, atropine gr. $\frac{1}{150}$, one hour preoperatively. In the extremely ill patients the morphia is eliminated and nembutal is reduced to a minimum.

In preparing the patient for regional anesthesia, nembutal gr. $1\frac{1}{2}$ to gr. 3, p.o. is given two hours before surgery to which is added morphine sulfate gr. $\frac{1}{6}$ to $\frac{1}{4}$ with scopolamine gr. $\frac{1}{150}$, one hour prior to surgery. Upon arrival at the operating room, the patient's reactions to the medication are noted. Blood pressure, pulse, and respirations are checked and compared with his preoperative readings. If the patient is drowsy or quiet, the paravertebral injection is then made and the reactions noted. When the effects of the medication appear insufficient or when the paravertebral injection disturbs the patient too much, intravenous morphia gr. $\frac{1}{6}$ is given. Adriani points out that intravenous morphia disappears from the circulation in one hour and clinically our experiences bear this out, for quite frequently the need for additional medication makes itself apparent and the same dose is repeated. It is to be remembered, however, that morphia given intravenously is about one-third more potent than the same dose given subcutaneously. The preparation and injection also differ from the subcutaneous method in that the dose is dissolved in 2 cc. of saline and given slowly, allowing two minutes for the injection. The usual doses employed are gr. $\frac{1}{8}$ to gr. $\frac{1}{6}$. Very rarely have we given gr. $\frac{1}{4}$. We have used this method frequently and have noted no untoward effects. Respirations in only a few instances have been mildly depressed. We do not hesitate to use it after a year of extensive trial. Occasionally, even under this régime, patients complain or become restless, but upon recovery have no memory of the procedure and undergo the next stage without any fear. We have gone into this discussion at some length, but it is our belief that the reason for local anesthesia falling into a measure of last resort in the past and its success in our hands depends primarily upon the adequate medication of the patient according to Guedel's[7] scale of metabolic activity. Tubercular patients have a definite tolerance for these drugs, perhaps because of their increased metabolic rate and common usage more than overbalances the depressant effect one would expect in such sickly individuals. Another factor which permits the use of larger and repeated doses is the fact that no depressant agent is added

TECHNIC OF ADMINISTRATION

Thoracoplasty. Two methods of anesthesia are employed for this procedure: (1) paravertebral block with 1 per cent novo-

caine plus infiltration in the line of incision, fascial layers and directly around the intercostals as they are exposed. Two drops of adrenalin are added to each 100 cc. of solutions, (2) the combination of cyclopropane-oxygen anesthesia with regional infiltration and paravertebral injection with novocaine, 1 per cent, without adrenalin. The latter is omitted in the presence of cyclopropane because of its sensitizing effect on the conduction mechanism of the heart.

Although either technic may be used for thoracoplasty, better results are obtained by individualizing each case with the selection of the anesthesia determined by careful analysis of the patient's condition. Thus vital capacity, activity of the disease, the amount of secretion, history of hemorrhage, contralateral disease or collapse procedure, physical and psychic state of the patient, history of drug sensitivity and operating time must be considered. All of these factors singly or collectively relate to (1) spread of disease and (2) operative morbidity and mortality.

As a consequence we consider those cases with (1) excessive secretions, (2) contralateral pneumothorax or thoracoplasty, (3) history of recent hemorrhage, (4) acute

disease and (5) extreme debilitation, to be the type best done under the regional anesthesia while the patients in better physical state receive cyclopropane-oxygen plus regional anesthesia.

FIG. 1. Anesthetic course of the average thoracoplasty.
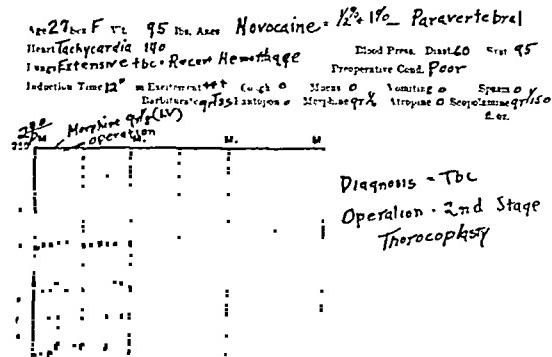
FIG. 2. Chart illustrating clinical course under paravertebral anesthesia.

The technic for the administration of cyclopropane-oxygen anesthesia is as follows:

The bag is inflated with four liters of oxygen and the flow of oxygen is set at 1,000 cc. per minute. The patient respires this atmosphere for a few breaths and then cyclopropane is allowed to course in at the rate of 500 cc. per minute until the eyelid reflex is lost and then oxygen is reduced to 500 cc. per minute and this proportion is maintained until the eyeballs have ceased their oscillations and the respirations are smooth, equal and quiet, indicating second plane of third-stage anesthesia. When this point is reached, the cyclopropane valve is closed until the need for higher concentration of the mixture makes itself evident and the surgeon is allowed to proceed. The time of induction varies from three to fifteen minutes with the average about five minutes.

The induction with cyclopropane is followed by the regional infiltration of the line of incision and the paravertebral injection with novocaine 1 per cent without adrenalin. The paravertebral injection is made by direct vision after the exposure of the intercostal space has been made. (Figs. 1 and 2.)

TECHNIC FOR PNEUMONECTOMY AND LOBECTOMY

These two procedures although differing somewhat in their anesthesia requirements and surgical handling are grouped together for consideration because of so many points of similarity.

The preparation for both is similar in that secretions are decreased by postural drainage and bronchoscopy if necessary. Preliminary pneumothorax is established in pneumonectomy cases if possible.

The plan of premedication of the patient for anesthesia follows the general pattern described above. Our patients receive 1½ to 3 gr. of nembutal two hours before surgery and gr. $\frac{1}{6}$ to $\frac{1}{4}$ of morphia one hour before surgery with atropine gr. $\frac{1}{100}$ to $\frac{1}{120}$. The patient is then brought to surgery and the throat cocainized and a cannula is inserted in a convenient vein in the ankle for fluid or blood if needed during operation. We have placed much stress on rather commonplace routine details, but it has been our experience that these procedures must be instituted before the operation is allowed to proceed.

The patient is then intubated with the technic described under the preparation of the patient. The tube and gas machine are connected and the induction with cyclopropane commences in the usual manner. The average time for the induction is about five minutes. Certain respiratory aberrations may be noted at this time, but these are usually due to either secretion, spasm or effects of pneumothorax. When respirations are under control, the patient is placed in the proper position, prepared and draped, and the infiltration of novocaine is then made.

With a tight system, little addition of cyclopropane will be necessary until the pleura is opened. The anesthetist will find it to his advantage to forestall the effects of the pleural reflex by increasing the concentration of cyclopropane a few minutes before this point is reached. When the pleura is opened, gentle positive pres-

sure will aid in transcending this phase smoothly. Mobilization of the lung evacuates secretion from the latent cavities, and excites vagovagal reflexes. When practical, the ligation of the bronchus should be
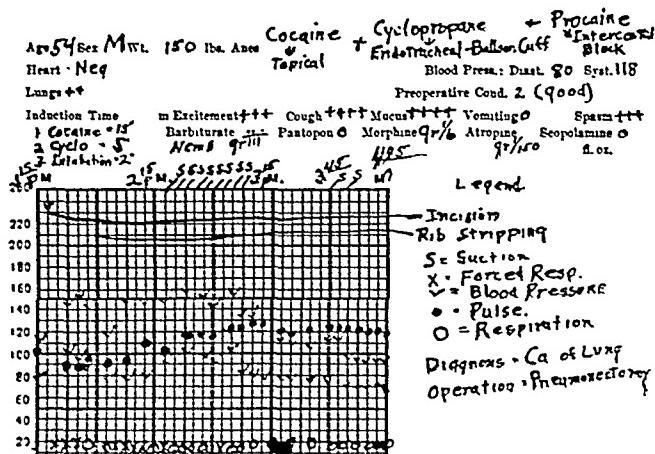
FIG. 3. Chart of some of the complications seen in pneumonectomy; marked cough reflex and secretion.

attempted as soon as possible in the wet cases for the relief of secretion and spasm, which are aggravated by continual manipulation. If spasm or cough occurs, moderate pressure on the bag will control the situation until the reflex subsides.

Just before completion of the closure of the thoracic cavity positive pressure is instituted under the surgeon's observation as to the response of the lung. The pressure is applied slowly and gradually built up. Anesthesia is maintained until the wound is closed. Bronchoscopy is then performed and all secretions aspirated. By passing oxygen through a special nipple the bronchoscope will make the transition from the anesthetic atmosphere to air less abrupt. (Fig. 3.)

TECHNIC FOR EXTRAPLEURAL PNEUMOTHORAX

Certain factors deserve consideration. First, the activity of the cough reflex from mediastinal stimulation, second, by providing quiet, even respirations, the surgeon is provided with ideal conditions for operating, and third, in the event of accidental opening of the pleura, means for application of positive pressure is essential.

We find a combination of cyclopropane inhalation and novocaine paravertebral injection with procaine the most satisfactory. Regional anesthesia alone fails to give the desired duration and does not control the cough reflex. Unsupplemented cyclopropane requires a higher concentration with consequently more depression of the patient. The technic is almost identical with that of thoracoplasty.

The procedure consists of: (1) placing the patient in the lateral thoracoplasty position; (2) inhalation with cyclopropane, using the gradual induction technic with the concentration of the gas varying between 15 per cent and 25 per cent; and (3) injection with 1½ per cent solutions of procaine paravertebrally and in the line of incision.

Lung Abscesses. There are a few cases in surgery which present more serious problems from either surgical or anesthetic angles than patients with lung abscesses. The fulminating infection produces a profound prostration of the patient, and to this are added the effects of mechanical obstruction to aeration of the lung, so that cyanosis, uncontrollable cough, with foul sputum, rapid pulse, and dyspnea complicate the choice of anesthesia.

Agents which will reduce the oxygen saturation still further cannot be used here, nor can inflammable gases or vapors be employed because of the use of cautery. Thus the anesthetist is left with the choice of regional, intravenous or rectal anesthesia. We have selected as the safest method, regional anesthesia with adequate premedication. Premedication is essential for the application of positive pressure with oxygen on the fully conscious patient from which he is apt to be more uncomfortable than from the surgical procedure. The combination of nembutal, morphia and scopolamine in judicious doses is given in the manner described previously under paravertebral anesthesia. The intravenous injection of morphia can be used to great advantage in these cases, particularly for the relief of cough.

Positive pressure with 100 per cent oxygen is helpful in these cases and is applied when the pleura is to be opened. It is used for a threefold purpose: (1) to retain the lung against the thoracic wall to prevent empyema, (2) to dam back the pus so that when the abscess is opened with the cautery the pus is forced outward instead of passing through the bronchial fistula, and (3) to afford the patient a forced oxygenation which apparently they need, as observed by improvement in color and general condition when the positive pressure is instituted. The pressure is maintained until the dressing and binder are fixed.

Procedure. The procedure is as follows: (1) medication, (2) paravertebral injection, and (3) positive pressure oxygen.

Empyema. Drainage of empyema is performed under regional anesthesia or cyclopropane-oxygen. When simple drainage is to be instituted, local infiltration is the simplest and most satisfactory. In the chronic type, however, infiltration may not be as well suited for the more extensive procedures involving resection of several ribs and thickened pleura. In these cases cyclopropane better serves the purpose.

Technic for Cardiac Surgery. Anesthesia for operations upon the heart is attended with technical difficulties for the surgeon in that he is contending with a constantly moving organ whose full activity is essential for the maintenance of the patient. Consequently, variations in pulse quality and rhythm may be expected upon handling this vital tissue and the surgeon and anesthetist must bear this in mind. The most serious complication that may occur is that of ventricular fibrillation.[8] Unless early detection with prompt therapeusis is performed, the outcome is fatal. For this reason a 10 cc. syringe is loaded with procaine,[9] ½ per cent solution and kept on the instrument table ready for immediate injection into the cardiac muscle should this complication develop.

Whether to use cyclopropane, ethylene or nitrous-oxide ether is a controversial

issue as is the necessity for intubation. Waters[10] states that there are no contra-indications for the use of the cyclopropane in experienced hands. Other observers do not recommend its use in cases in which there are known disturbances in the[11] conduction mechanism of the heart. We believe, however, that these patients require an anesthetic with minimum toxicity and maximum oxygenation to spare an already embarrassed circulation. The cases which we have done with cyclopropane endo-tracheally have impressed us with the fact that this agent conforms with this precept.

We believe that these cases should be intubated so that a patent airway is assured at all times. Straining, spasm, cough or any interruption in the normal respiratory rhythm embarrasses both the surgeon and anesthetist. One of the early pericardec-tomies was done under a combination of local anesthesia and cyclopropane, but without an endotracheal tube. The patient was a robust, excitable male in the middle age group. His induction was prolonged by a moderate struggle. His respirations were rough, even with nasal and oral airways so that he was partially obstructed, yet his color was apparently unaffected. Exposure of the field was made difficult by the uneven respirations. As a result, the operating time was increased, but in this particular case, in spite of the difficulties, the patient made an uneventful recovery. Another factor worth noting was that no arrhythmias were detected under these far from ideal conditions. The contrast between the nonintubated case and the intubated cases was quite marked as far as operating conditions were concerned.

Procedure. The procedure is as follows: (1) premedication, (2) intubation, either under local or general anesthesia, (3) cyclopropane and oxygen anesthesia in 15 to 20 per cent concentrations, (3) regional anesthesia with novocain, 1 per cent.

Technic for Transpleural Approaches for Diaphragmatic Hernia and Tumors of the Lower End of the Esophagus or Fundus of the Stomach. For this procedure, we have

borrowed from our experiences with other thoracic operations. The course these patients have taken has been of particular
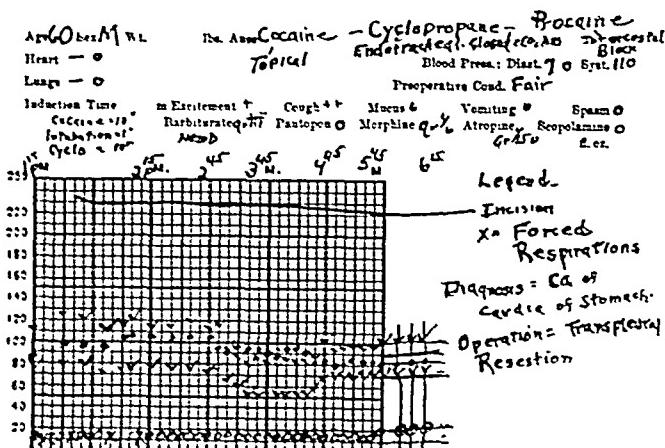
Fig. 4. Anesthesia chart for transpleural approach for resection of cardia of stomach.

interest and value. Here we are not dealing with an impaired respiratory or circulatory system, yet we must remember certain fundamental essentials. A placid field in which the activity of the diaphragm must be curtailed and billowing effect of the lung removed, can be obtained by intratracheal cyclopropane followed by injection of the phrenic nerve with novocaine when the thorax is opened. The lung collapses so that it is necessary to re-expand it at fifteen to twenty minute intervals. With this approach and technic, certain disturbing factors have been greatly ameliorated. Relaxation is no problem, for with the ribs removed and the tissues retracted, the exposure of the lower esophagus and upper stomach is obtained and maintained with facility. The ballooning bowel of the abdominal contents is absent, as are the usual complications of chest pathology. These patients seem to tolerate these procedures fairly well. (Fig. 4.)

Procedure. The procedure for the preceding technic is as follows: (1) medication, (2) Levine tube through the nose for gastric drainage is employed for stomach cases, (3) intubation under topical cocaine or larocaine, (4) regional infiltration and paravertebral block with novocaine ½ to 1 per cent, (5) gradual induction with cyclopropane in concentrations of 15 to 20 per

cent, and (6) injection of the phrenic nerve with novocaine ½ per cent.

COMPLICATION OF CYCLOPROPANE

Some of the more common complications will be considered:

1. *Cardiac Arrhythmia.* Robbins[12] concludes that arrhythmias occur with cyclopropane when morphia is added to the pentobarbital sodium and scopolamine for premedication. In this series, a group of patients were run with this technic but some still developed minor cardiac arrhythmias, therefore, morphia has not been eliminated in this series.

The arrhythmias observed have not been severe and have all disappeared before the operation was finished. It is believed that in some cases an addition of oxygen to the mixture, or shifting to nitrous-oxygen for a few minutes has caused the arrhythmia to disappear. On the other hand, the majority have vanished[13] with deepening the level of anesthesia. It has been observed, however, that with the perfected induction, namely, carrying the patient to a second plane of third stage (Guedel), before even preparing the field of operation, and combining cyclopropane-oxygen with regional novocaine anesthesia has practically eliminated arrhythmias. Another observation has been that with the reflexes under complete control (in second plane of third stage) the reflex spasm of the larynx (glottis) together with cardiac arrhythmias have been practically eliminated. A quick and more complete induction has been facilitated by substituting atropine for scopolamine in the preliminary medication when cyclopropane is used.

2. *Apnea.* As has been stated, in the patient with extensive bilateral disease, the absorptive surface of the lung is reduced both for oxygen and anesthetic. For this reason the more extensive the disease, the more difficult the administration of the anesthetic. The tidal air becomes lowered and the reflexes are more difficult to control. It is in this type of patient that complications are more apt to occur. The margin between the normal functioning respiratory center and apnea (paralysis of the respiratory center) is very narrow. As a result, the induction is usually prolonged and apnea develops very easily and very often is repeated several times during the operation. One minute the patient is phonating and crowing with laryngeal stridor and the next minute he is in complete apnea. In experienced hands this is not a serious complication. With sufficient oxygen under controlled respirations by rhythmical pressure on the re-breathing bag the patient is kept in a perfectly normal clinical course. As soon as the cyclopropane concentration in the respiratory center is lowered and the hydrogen ion concentration is raised, the patient spontaneously breathes normally, with return of normal respiratory center function. To prevent return of respiratory spasm and phonation, cyclopropane has to be added immediately. Guedel produces[13] apnea intentionally to relieve the patient of arrhythmia, or to suspend the motion of the lung in intrathoracic operations.

Hypoxia, or state of insufficient oxygen, may also develop with hypopnea, and if unrecognized and untreated may lead to apnea with further deprivation of oxygen leading to anoxia. The hypopnea may be due to the action of an overconcentration of the anesthetic on the respiratory center or a partially obstructed airway. With cyclopropane the color of the patient is no guide to the degree of suboxygenation as the patient remains pink, but the synchronization of the chest and abdomen disappears, the blood pressure becomes elevated and arrhythmia of the heart may develop. The treatment is establishment of a patent airway and adding oxygen under rhythmical positive pressure if necessary.

The possible causes of apnea are: (1) Insufficient depth of anesthesia with cyclopropane with reflex respiratory spasm; (2) narrow margin between apnea and reflex control level of anesthesia; (3) excessive carbon dioxide absorption and anesthetic

concentration; (4) excessive premedication, and (5) hypoxia.

3. *Blood Pressure Variation.* The blood pressure variations observed in chest surgery have been different from those seen in other types of operations.

In the emotionally stable, good conditioned patient, a level clinical course may be maintained in all the various types of chest operations. In the patient with high metabolic rate, and especially with debility and low vital capacity, whether given regional anesthesia and cyclopropane-oxygen combined or paravertebral anesthesia alone, the blood pressure usually rises rapidly with a corresponding drop in the course of one-half hour.

Lobectomies and pneumonectomies for bronchiectasis and lung tumor follow a remarkable normal blood pressure course with the combination of regional anesthesia and intratracheal cyclopropane-oxygen, even for operations lasting three to six hours. If there is excessive loss of blood or difficulty in the lysis of adhesions, or if extreme traction on the lung is required, a marked drop in blood pressure usually ensues.

In the first cases of the series, the few that were done with cyclopropane oxygen without regional anesthesia showed much more depression of blood pressure.

When the blood pressure falls twenty points below the patient's preoperative level, various drugs may be used. About five years ago, it was thought that coramine, 2 cc. subcutaneously, gave satisfactory results. This was replaced by ephedrine, gr. 3/4, pitressin 1/2 cc. (Bourne[14]) which was also believed to stimulate the circulation. The results of both of these technics were very questionable as to whether the blood pressure was effected by them or the fluid therapy. In the last year neosynephrine,[15] m. 1, intravenously or m. 4 intramuscularly, has given very definite beneficial results in almost 100 per cent of these cases. If the desired results are not obtained after fifteen minutes, the same dosage is repeated.

4. *Loss of Body Fluids.* To counteract the loss of blood and body fluids and to prevent depression of the circulation, glucose in saline, 5 per cent, is administered intravenously before the operation is started after the induction of cyclopropane. In regional anesthesia local novocaine, 1 per cent, is used at the site of venopuncture. During the operation, 1,500 to 2,000 cc. of fluid is administered. If the circulation fails in spite of glucose solution, 500 cc. of donor's blood is added to the venoclysis. Patients with marked debility and those for lobectomy and pneumonectomy receive transfusions of blood for supportive or preventive measures preoperatively.

5. *Nausea and Vomiting.* Vomiting and nausea are a definite sequelae of cyclopropane anesthesia. The large majority of patients will vomit at least once on the revival of the vomiting reflex, and a small proportion have spells of nausea and vomiting for several hours; but the degree of this complication is not of the same intensity as with ether, and there is not the manifestations of acidosis or prostration with this gas as there is with ether. About 1 per cent of the patients will have spells of nausea and vomiting for twenty-four hours.

Explosions. Unfortunately, due to several fatal explosions, some medical groups have condemned cyclopropane. According to the Bureau of Mines, ether is the highest explosive of all anesthetics in the proper proportion with oxygen. Nitrous-oxide-ether mixtures have the highest explosive range.

Waters has administered cyclopropane to[16] 17,800 patients at the Wisconsin General Hospital since 1932 and Rovenstein to more than 50,000 patients in five years at the Bellevue Hospital, with no explosions. The only precaution used at these hospitals is personal contact by the anesthetist with the patient and with all objects within his reach before the anesthetic mixture is used, in order to equalize potentials of static electricity and to eliminate fire or electric current from the operating room.

The Horton megohn has been used in Boston since 1939. From a megohn attached to the gas machine four wire leads pass to the anesthetist, patient, operating table and ground. This apparatus equalizes the potentials of static electricity in all of these objects. By requiring everyone coming into the region of this hookup to contact the apparatus remote from the rebreathing circuit, all potentials of static electricity are eliminated. Other precautionary measures which should be observed are the prevention of fire or heat and electrical apparatus of any sort from coming in contact with the anesthetic mixture in the region of the rebreathing circuit of the gas apparatus. All electrical appliances with the exception of the low powered laryngoscope and extension operating lamps have been discarded. The surgeons are of the opinion that they would rather do without the electrosurgical instruments and appliances than to give up the benefits of cyclopropane to the patient.

POSTOPERATIVE CARE

At the earliest moment, usually when the surgeon is closing the chest cavity, in open thoracic operations or suturing the skin in extrapleural cases, the anesthesia is lightened by washing the patient's respiratory tract with 100 per cent oxygen under 5 to 6 mm. of mercury pressure. If this procedure is timed properly, the cough reflex and early return to consciousness may be anticipated. As soon as the dressing is applied a No. 16 to 20 gauge French catheter is inserted into the trachea through the nose for aspiration of secretions from pharynx and trachea.

By this time the patient is conscious or semiconscious. Transfer to bed is made at once and the patient is given oxygen by tent, oropharyngeal catheter, or B. L. B. Mask administration. Oxygen therapy is continued until the blood pressure, pulse, respiration and color are stabilized within a normal clinical range.

In placing the patient in bed, except in pneumolysis and extrapleural pneumo-thorax, the operative side is always dependent for hemostasis, to relieve pressure on the healthiest lung, to aid respiratory exchange and to support the circulation. A pillow is placed under the back to relieve pressure on the unaffected lung so that the patient lies at an angle of forty-five degrees.

Intravenous glucose 5 per cent is started in the arm at once. Dependent upon the amount of intravenous fluids the patient has received during the operation, 3,000 cc. is well tolerated for the average patient in six hours. If the patient is still in any degree of shock, a transfusion of donor's blood is run through the intravenous system.

If the blood pressure is below normal or failing, neosynephrine m. 1 is injected directly into the intravenous infusion.

The opiates are given sparingly to prevent postoperative depression of respiration and circulation. By limiting the sedation, the patient is more able to cough and raise secretions, thus decreasing the possibility of the spread of disease and atalectasis. Pantopon is preferred, as it has less depressing effect on the respirations and clinically produces less nausea and vomiting than morphia. If pantopon causes any untoward complications, dilaudid is substituted.

TABLE I

Type of Cases	No. of Cases	No. of Deaths
Thoracoplasty.	1939	43
Extrapleural pneumonolysis	39	
Open pneumolysis	6	
Closed pneumolysis	173	
Lobectomy..	77	11
Pneumonectomy	54	7
Lung abscess	115	24
Empyema	5	
Cardiac surgery	5	
Diaphragmatic hernia	5	
Transpleural gastric resection	2	
Total......	2420	85

The deaths in this series from all causes in a postoperative period of three months

have been listed. In the pneumonectomy group with the exception of the neoplasms, there has been only one death in the last

nausea and vomiting in the first twenty-four hours, her reactions were normal. On the fourth postoperative day, she lapsed
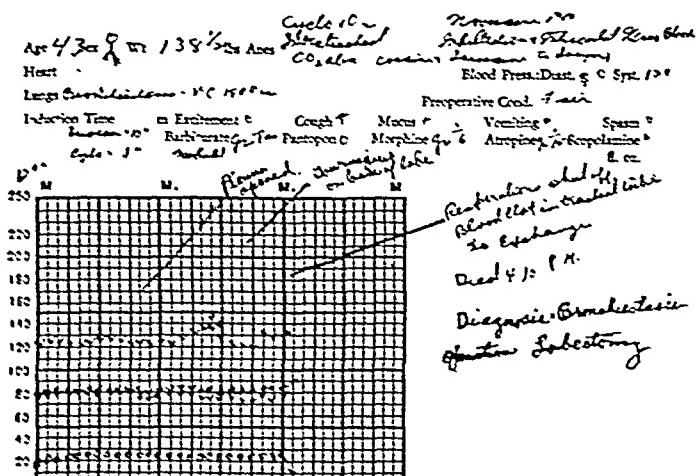
FIG. 5. Hemorrhage blocking the bronchi as a cause of death.

twenty-eight cases, and that was due to a sulfanilamide reaction.

Deaths directly attributed to the anesthesia number six, of which none is found in the large thoracoplasty group.

Hemorrhage in the bronchus is a hazard which is difficult to overcome. In the chart below of a lobectomy, it will be seen that this accident requires but a few minutes to alter an uneventful course to that of a fatal outcome. The clot in the bifurcation of the trachea was too large and solid to be aspirated. (Fig. 5.)

Shock was the prime factor in the death of a forty-one-year old male with carcinoma of the lung, for which pneumonectomy was performed. At the conclusion of a four-hour operation, his pulse was 130 and blood pressure 90/60. Upon his return to the ward, in spite of transfusions and oxygen, he developed an irriversible state of shock and expired one hour later. An elevated blood pressure with a rapid pulse during the first hour of surgery may have been evidences of a hypoxic state from which he did not recover despite a tranquil course during the last three hours of surgery.

The other fatality in the pneumonectomy group was due to diabetic coma. The clinical chart of this twenty-four-year old, white female with pulmonary tuberculosis revealed no untoward changes. Except for

into coma with the characteristic picture of diabetic acidosis and expired.

The cause of death in a twenty-eight-year old, white female with bronchiectasis for which lobectomy was instituted is obscure. Although the patient was under anesthesia for seven hours, during which time there were no periods of obstruction or apnea, she showed only slight variations in blood pressure and pulse. Her cough reflex had returned for completion of the postoperative bronchoscopy. The following morning she was semicomatose and showed a paresis of the left side with a positive Babinski test. A left-sided paralysis soon followed and she expired. This case appears similar to the encephalopathy described by Courville[17] in nitrous oxide and ether anesthesia, but wherein the anoxia developed in this instance is puzzling since the common factors as obstruction and stagnation were not present.

Death occurred in a fourteen-year old boy with massive fibrosarcoma which occupied two-thirds of the thorax. At the end of a three-hour attempt to afford palliative relief, the heart stopped while dissection of the tumor from this organ was taking place. The boy ran a pulse of 140 and his respirations were shallow throughout, although his color and blood pressure were good.

A cerebral accident, whether embolic or hemorrhagic was the cause of a fatality in the lung abscess series. The patient was a sixty-five-year old, plethoric, hypertensive male who was being drained for the second time. The anesthesia was a procaine hydrochloride infiltration with positive pressure oxygen. Following cauterization of the abscess, the patient became irrational and began to struggle. Administration of oxygen was continued but the patient expired.

SUMMARY

In summary, cyclopropane-oxygen combined with regional novocaine anesthesia is employed in operations for empyema, selected thoracoplasties, extrapleural pneumothorax, pneumonectomies, lobectomies, diaphragmatic hernia, esophageal and upper stomach and cardiac surgery.

Thoracoplasties in tubercular patients in very poor physical state are performed with paravertebral novocaine 1 per cent without cyclopropane-oxygen. Local infiltration with novocaine is employed solely in internal pneumolysis and with positive pressure 100 per cent oxygen in lung abscess.

Intubation with balloon cuff catheter is carried out in pneumonectomies, lobectomies, diaphragmatic hernia, esophageal and stomach surgery when performed through transpleural approach and cardiac operations.

Positive pressure is used only when one or both pleural cavities are intentionally or accidentally opened, and for lung abscess operations.

These technics employed in the different types of thoracic surgery have approached the ideal of anesthetic procedures. They have been proved to be safe for the patient as shown by the extremely low mortality and morbidity. The benefits derived from these methods are: (1) The elimination of irritating and toxic anesthetics; (2) the prevention of hypoxia of the respiratory center and vital organs; (3) the prevention of excessive secretions; (4) they provide an ideal means of controlling excessive secretions; (5) a rapid, smooth induction is made possible in the large majority of cases; (6) control of reflexes during anesthesia is maintained with low concentration of anesthesia and a high concentration of oxygen, and (7) early return of cough reflex and consciousness is made possible.

CONCLUSIONS

Procedures of anesthesia for thoracic surgery have been presented. Preoperative treatment, care of the patient during anesthesia and postoperative management have been outlined.

Technics for various thoracic operations, the usual complications and their treatment have been described.

As a result of our experiences with over 2,000 cases, we find that cyclopropane is a safe anesthetic agent, but that its value is enhanced by the supplement of regional anesthesia. We have seen no untoward effects from routine intubation in the intrathoracic procedures, or in the operations on the heart, esophagus or stomach; on the contrary, the intratracheal tube with the inflatable cuff has been a considerable if not invaluable adjunct.

Differential pressures have been employed in lobectomies and lung abscesses without incident.

The details of six operative deaths have been portrayed. Out of these only two may be said to have contributed directly to the fatal conclusion.

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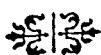
GRAVES' disease in children begins usually on a previously existing simple goiter or possibly seldom primarily as such. Just such children furnish the best argument for those who contend that there is a preceding simple goiter in all cases of Graves' disease, adults as well as children; for the papillations are always formed in widely distended follicles. Acute toxic goiter without eye signs is rare in children but may precede the exophthalmos by some months.

POSTOPERATIVE PULMONARY ATELECTASIS

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POSTOPERATIVE pulmonary atelectasis and the more extensive massive collapse are receiving progressively more consideration as possible complications of operative procedures. In many localities, however, they are still being considered as pneumonias and their follow-up course will certainly bear this out, since an unrelieved atelectasis will, in a great many cases, terminate as a pneumonitis or pneumonia. Too many men have the idea that the only true expression of this condition has, as its minimum lesion, a complete lobar collapse with its mediastinal shift, and fail to realize that there are minor lobular involvements which, although they do but rarely cause fatalities, contribute considerably to postoperative morbidity, and in some instances lead to pneumonia.

Postoperative atelectasis was first described by William Pasteur,[1] an Englishman, in 1908. His original article was followed by several more in which he established massive collapse of the lung as a postoperative clinical entity. It was not until 1921 that the first report of this condition was made in the American literature by Scrimger,[2] of Montreal, and in 1924 by Leopold,[3] of Philadelphia. Since that time there has been increasing knowledge and recognition of the rôle of atelectasis as a possible pulmonary complication post operatively, and it is gradually replacing the previously all-responsible pneumonia.

Considerable confusion arises in the present concept of this condition, possibly from the inconcise application of the terms and boundaries of the terms, atelectasis and collapse. They are generally used interchangeably; for consistency it would seem better to make a distinction. One can classify all lesions of the type about to be described as atelectasis, and grade them in

extent as lobular, lobar,[1,8] and multilobar, depending on the extent of involvement. These terms are logical and self-explanatory; lobar and multilobar should designate involvement of the greater portion of one lobe, or of more than one lobe, whichever the case may be, with increased intrapleural negative pressure, extensive collapse of alveoli, mediastinal shift and elevated diaphragm. These correspond more or less in extent to the more popular massive collapse and are truly massive atelectasis. The lobular lesions are comparable to those in bronchopneumonia, being patchy or confluent, the findings are more indefinite and the extent of involvement less than that found in the lobar type.

In true collapse of the lung, an entity in itself, the picture is somewhat different.[4] In it, the underlying pathology is due to a decrease in intrapleural pressure (decrease in negative pressure), rather than an increase in negative pressure as is seen in atelectasis. Using artificial pneumothorax as an example, the picture is that of a complete collapse of the lung due to the introduction of air or gas (positive pressure) by some mechanism into the pleural cavity. The mediastinal shift, if any, is away from the involved lung. On x-ray, the collapsed area shows very little density and is only faintly visible, a decidedly different picture than that found in atelectasis. Atelectatic lung tissue contains some air; collapsed lung tissue none.[7] Atelectasis represents the changes found in the lung due to increased intrapleural pressure; collapse represents those changes due to decreased pressure. The term, "collapse," will be used henceforth in this article as denoting a pathological state of the alveoli, rather than an entity as referred to above, reserv-

ing "atelectasis" as the term to be used to include the whole group to be described.

Habliston,[5] and Coryllos and Birnbaum,[6] have made studies that confirm the fact that in atelectasis there is an increase in negative pressure in the pleural cavity of the involved lung. Normal intrathoracic pressure is said to be about minus 70 mm. of water on inspiration and minus 40 mm. on expiration. In atelectasis, the pressure is reported as ranging from minus 150 to 250 on inspiration to a minus 75 to 150 on expiration, or more. One case is reported as being as high as 442 mm. over 337.[5]

By stressing some of the more salient points in the development and course of atelectasis and emphasizing the need for early effective treatment, some attention might be brought to the value of postoperative care which is all too frequently neglected and certainly not emphasized enough in the medical literature. To many it may seem that too much stress is laid on conditions that are considered as logical sequelae to operations, but timely treatment of these so-called minor conditions will more than repay the surgeon for his effort in detecting them.

Atelectasis is not the only offending lesion in postoperative complications, but is frequent enough and important enough to deserve special note. Although no definite incidence can be determined, it is safe to say that atelectasis constitutes a considerable proportion of postoperative pulmonary complications, which in turn constitute a major portion of early postoperative pathology.

ETIOLOGY

Some writers believe that atelectasis is caused entirely by some form of bronchial obstruction, principally a mucous plug that has lodged in the bronchi; there are others who believe that this is combined with the added factor of diaphragmatic paralysis. Since the majority of lesions occur at the bases of the lungs, it is quite logical to assume that the diaphragm and also the subdiaphragmatic viscera play a

part in its causation. In the recumbent position assumed by the patient both during the operation and following it, the lower lobe bronchi are not in a dependent position and should be no more prone to plugging than any other lobe, still the incidence in the lower lobes is much greater. Whether diminished excursion of the diaphragm or splinting due to pressure from below during the operation, due to reflex paralysis from trauma to the celiac plexus or due to generalized debility and surgical shock, plays a part in the development of atelectasis, is problematical, but it seems very probable. Plugging of the bronchi is present in the majority of cases, whether primarily or secondarily, and probably plays a most prominent part in the causation of lobar atelectasis, while on a smaller scale plugging of the bronchioles causes the lobular lesions. The rôle of the diaphragm, however, must not be minimized.

Working on the assumption that plugging of the bronchus from secretions or foreign bodies present there, and factors diminishing expansion of the lung are the chief causes of atelectasis, there are numerous contributing conditions that play a part. Approaching the situation from the standpoint of the bronchi, we have the chief and most popular cause in chronic bronchitis. With the already productive nature of bronchitis, there is an added incentive in the use of irritating inhalation anesthetics. Peculiarly enough, atelectasis occurs after spinal anesthesia and causes an associated hypersecretion of the bronchial mucosa. The statement is frequently made that atelectasis is as frequent after spinal or local anesthesia as it is after inhalation; this is probably true only in part. Upper abdominal operations are particularly apt to cause atelectasis with any type of anesthesia, while in nonabdominal operations the incidence is contrarily low. Rink[8] sets the percentage of chest (all types) complications after abdominal operations as 14, after nonabdominal as 1 per cent. Elkin[13] states that after upper

abdominal operation, 10 per cent of his patients developed serious pulmonary complications, while the morbidity of patients postoperatively in all cases was 3 per cent with 40 per cent of those dying. The frequency of chest complications following upper abdominal procedures is probably enhanced by the splinting and subsequent paralysis of the diaphragm from packing and retraction at the time of operation. Either at that time, or later, from temporary weakness of the diaphragm, there is collapse of the alveoli at the base of the lung and diminished aeration. A combination of factors causes secretion of the bronchi with stasis and later plugging. There appear to be two modes of development of atelectasis: One is the series of changes that follows an out-and-out plugging of a bronchus or bronchiole with subsequent absorption of air distal to the occlusion and a collapse; the other is that which follows a collapse of lung tissue from pressure below with formation of a secondary bronchial plug from stasis of bronchial secretions. In most cases, no doubt, there is a combination of these factors to form the atelectatic lesion.

Diminished aeration of the lungs predisposes to the development of atelectasis. This, together with abolition of the cough reflex, would promote stasis of material in the bronchi which could lead to plugging.

Probably a factor in addition to diaphragmatic paralysis is the splinting of the abdominal wall musculature either reflexly from underlying peritoneal irritation, or from the voluntary response of the patient to pain in the area of the incision. This could materially decrease the depth of respirations. It takes on added significance in the male, the so-called abdominal breather. In support of this is the much greater incidence of atelectasis in men than in women, 4:1. The greater incidence of bronchitis in the male also claims consideration.

Prolonged recumbent position is a factor. Postoperative distention, especially from an acutely dilated stomach may cause enough pressure to splint the diaphragm in an elevated position, thereby causing pressure on the base of the lung. There is also a definite correlation between the incidence of atelectasis and the presence of drainage for suppurative appendicitis.[9] The incidence of pulmonary complications increases with age, coincident with the increase in prevalence of bronchitis, and also of the greater reaction of a patient to pain from an operation. The injudicious use of morphine postoperatively, although beneficial for the relief of pain, in those doses suppresses respirations sufficiently to be a factor. Elkin,[13] however, advocates a sufficient amount of morphine to allay the pain of coughing.

A study would probably show that the incidence of pulmonary complications following operation is on the decline with the advent of improved methods in anesthesiology, both in the choice of anesthetic agents and the improved methods of administration. With the improvement of surgical technic, the prolonged deep anesthesia of bygone days has been largely abolished.

In institutions using the newer types of anesthesia, it is not uncommon to hear the "old-guard" of both doctors and nurses rally to the side of the old styled anesthetist with the statement that the incidence of complications is greater with the newer closed methods of anesthesia in vogue. In previous times anesthesia was given with partial anoxia and the associate increase of pulmonary carbon-dioxide tension in the alveoli; this kept the patient breathing deeply and in that way provided one of the most potent prophylactics against the development of atelectasis. Although this state may have been beneficial in one respect, it has been found to be very detrimental to body physiology.

With the apparent variability in findings, the numerous factors in the cause and development of atelectasis, and the multiplicity of contributions, it is seen that postoperative atelectasis is a complex state, and because of its relative infancy is open

to considerable controversy and leaves much to be learned by further observation.

PATHOLOGY

In the more extensive lesions with involvement of one or more lobes, the pathology is clear cut. There is a collapse of the lung tissue with a resultant shifting of the mediastinum and heart to the involved side along with elevation of the diaphragm caused by the increase of negative pressure in the pleural cavity. At first there is a collapse of the alveoli in the involved area, but after several hours, if the condition is unrelieved, the lung tissue becomes moist and edematous. After twenty-four to forty-eight hours, the process becomes irreversible, interstitial changes take place, and pneumonia and later possibly bronchiectasis or fibrosis ensue. Combined with any of these conditions, there may be a superimposed suppuration. This is true in the acute upper respiratory infections in which the aspiration of infected discharge and secretions would lead to more severe lesions and would be more apt to produce a suppurative sequel to the atelectatic state.

In the lesser lobular lesions, the picture is more variable. The areas of involvement are patchy and the presence of clinical signs depends entirely on the location of the involvement. If the areas are near the surface of the lung, findings such as diminished breath sounds, rales, etc., are in evidence. If the lesion is basilar, in all probability findings will include, in addition, elevation and diminished excursion of the diaphragm. Should the lesion be more diffuse, the findings would more closely resemble those of the lobar type. Apparently the reaction of the body with fever, tachycardia, hyperpnea and possibly dyspnea and cyanosis, is due to the rapidity of onset of the condition, for it has been noted that in the more slowly developing lesions in the chest, that is, not postoperatively with associated atelectasis, these findings are less marked and are often absent.[4]

SYMPTOMATOLOGY AND DIAGNOSIS

There are several factors that should be considered before entering into a discussion of the symptomatology of atelectasis. Some of the statements may appear quite dogmatic at first glance, but to atelectatic enthusiasts, they seem quite logical. First of all, it might be stated that in uncomplicated surgery, that is surgery in non-infected cases, and cases which have no associated infection to the condition being operated, any pathological condition occurring in the first twenty-four hours, if there is a febrile response, is in most cases the result of anesthesia and can be strongly suspected as being intrapulmonary. One of the first and most reliable signs is a sudden elevation of fever above that normally thought to be a reaction to surgery. Such diseases as urinary tract infection, upper respiratory infections and visible evidences of infection elsewhere should be eliminated as factors. A routine chest examination should be made for there might be a lesion present in addition to pathology elsewhere. In spite of the fact that no pathogonomonic signs are found in the chest, and if the fever is associated with elevation of the pulse and respirations above what would seemingly be the level for that height of fever, on probabilities, the patient should be given treatment for atelectasis. Certainly a portion of these cases will be pneumonias, or one of the less common pulmonary lesions, but a much smaller percentage than is commonly thought. Others may be the expression of an endocarditis or septicemia, the rekindling of an old infection, etc., but these will be detected in due time and no harm has been done by the type of treatment instituted for atelectasis.

Another consideration is the use of rectal temperatures. Too much emphasis cannot be placed on the value of periodic rectal temperature readings postoperatively in the suspected period. There is a good deal of inaccuracy in mouth temperatures in an operative patient who breathes partially

through his mouth either because of some dyspnea, stupor or the general lack of concentration which follows anesthesia. Rectal temperature readings give an accurate account of the febrile response of the body and in a condition such as this are invaluable.

One of the chances for error in examination of the patient lies in the postural diminution of aeration of the lung on the splinted underside when the patient is turned to be examined. Turning of the patient, however, is not to be condemned but should be condoned, for this procedure frequently aids in dislodging small plugs of mucus in the bronchial ramifications by increasing the depth of breathing in the upper lung and also placing it in a better position for drainage.

As stated before, the most suggestive finding in the postoperative atelectatic patient is the sudden rise in temperature above average in the first twenty-four hours after operation and generally in the first eight hours. Usually the rapidity of rise and the degree of rise are an indication of the extent of involvement, but this is not necessarily true. With this rise in fever, there is an acceleration of pulse out of proportion to the fever. This again is quite significant, for it gives an indication as to the amount of shift of the mediastinum and heart. Generally the pulse rate is from 120 to 140 beats per minute, but may run higher in the more severe cases. Concomitant with the rise in temperature and pulse is the rise in respiratory rate. This may be mild or severe depending on the amount of lung space compressed. Commonly in the less severe lesions, the rate becomes 28 to 30 per minute, but in the severe cases, it may rise to 50 or 60. Cyanosis of some degree is usually present; dyspnea also varies with the extent of the lesion. Dilatation of the ali nasi is often suggestive.

In examining the chest, numerous variable and often unconfirmatory signs are found. The first thing to be observed is the position of the apical impulse of the heart,

as to whether there is a shift in any direction, that is, to the right or left or even upward. Minor deviations are frequently overlooked because of the normal variation in the location of the impulse, and also the indefinite fixation before operation, which, although remediable, may be sometimes justified. Typically, the lungs should show an area or areas of diminished breath sounds, depending on the extent of the involvement. If these are absent, it may frequently be assumed that the area of atelectasis is not on the surface where it can be detected. Bronchial breathing at times can be heard in areas where the obstruction is only partial and the breath sounds are conducted to the surface by the condensed collapsed lung. At times so-called atelectatic rales are present emanating from the distending alveoli adjacent to the collapse. The lung findings also may be overshadowed by moist rales that are caused by the productive bronchitis already present. Edema that has developed from an unrelieved condition may cause rales if some air is transmitted into the atelectatic area. Changes in the conduction of fremitus and of breath sounds, lag of the chest wall, dullness to percussion, etc., aid in confirming the picture. Highly suggestive is the spontaneous cough and sometimes expectoration of mucoid or mucopurulent material when the patient is turned on the uninvolved side. Some men have attempted to correlate the vital capacity of the lungs postoperatively, but there have been no conclusions as to the association with pulmonary conditions. Logically, the capacity of the lungs should be diminished according to the degree of involvement.

Because of the added expense, the use of x-ray is usually omitted in most private institutions, unless demanded. The typical finding is an area of density showing the involvement of the lung area with a mediastinal shift and elevation of the diaphragm depending on the degree of involvement. The appearance of a shadow on the x-ray is said to depend on the existence of edema

and inflammation in the collapsed portion of the lung. This reaction takes place several hours after the onset, so it is impossible to say whether the very early lesions, especially the minimal ones, would produce a shadow. In the more extensive lobar involvement there is also a narrowing of the costal interspaces.

One must not forget that atelectasis does not always occur immediately following operation. It can occur after several days and has been known to recur several times. The development of these cases depends upon the presence of material in the bronchi which on occasion plugs them and atelectasis ensues.

Atelectasis also occurs from obstructive lesions such as neoplasms, the aspiration of foreign material, etc., but these conditions are not in the scope of this article.

The duration of the atelectatic state depends on the nature and ease of eradication of the condition that prevents aeration and re-expansion of the lung. One might reasonably question the accuracy of diagnosis in lesions, which often expectorate no mucous plug, to at least give some definite evidence of the existence of atelectasis. It certainly may be assumed that in a case after treatment that shows an immediate and almost dramatic drop of the temperature, pulse and respirations to almost normal and remaining there, has been relieved of an atelectasis. In my observation, the return to normal or thereabouts of the thermal, circulatory and respiratory systems has been the criterion for relief of the condition. Chest findings are in the main unreliable. Usually, there is return of breath sounds of some degree following the removal of the bronchial obstruction, however, the remaining signs sometimes take several days to return to normal, especially if the condition is of several hours' duration and edema has developed, the so-called drowned lung.[1]

Atelectasis may be confused with all types of pulmonary lesions and differentiation is often difficult. The use of x-ray is beneficial in differentiation and should be resorted to when doubt arises. Confusion with pleural effusion can be allayed by the use of thorocentesis.

TREATMENT

One may anticipate to a certain extent the type of patient that will develop atelectasis. The acute processes of the respiratory tract so frequently cause severe pulmonary complications following operation, that experience has taught this to be a definite contraindication to any surgery unless it is urgent. Chronic bronchitis, bronchiectasis or any of the productive processes of the respiratory tree are prone to be troublesome. Smoking is definitely irritating in certain individuals, causing a productive bronchitis and cough. In these cases, it might be wise to suspend the use of tobacco both before and after the operation, especially before. In addition to trying to relieve these conditions as much as possible preoperatively, it is quite important to make an intelligent choice of anesthetic. Because of the irritant action of ether, it should be omitted, if possible, and a less irritating agent be substituted. This decision becomes mandatory in the more extensive lesions of the lungs. Intratracheal anesthesia is becoming more and more popular and gives the advantage of direct aspiration of the trachea and upper bronchi, both during anesthesia and immediately following operation. However, it must be remembered that a tube in the trachea is irritating and may do much to aggrevate a pre-existing affair. Premedication should be given to diminish bronchial secretions, also smaller, less suppressing doses of opiates than are commonly used.

Treatment of atelectasis is directed mainly at the release of mucus in the bronchi and re-expansion of the lung. The patient should be protected against exposure at any time and general resistance maintained by combatting shock. Proper preparation before operation is quite essential and the gentle handling of tissues during technical procedure should be emphasized. Following operation, there

are several prophylactic measures that can be taken. Rebreathing deeply of the patient with a carbon-dioxide and oxygen (5 to 10 per cent carbon-dioxide in oxygen) mixture before the patient awakens from the anesthetic, is frequently practiced. This undoubtedly re-expands areas in the lungs by promoting deep breathing. However, since the patient is not awake at that time, further co-operation in breathing deeply or in expectorating cannot as yet be obtained. After the patient has reacted from anesthesia, carbon-dioxide inhalations can be instituted at intervals of from fifteen minutes to an hour for several repeated doses. Frequent changes in position are advisable as a routine in patients predisposed to forming pulmonary complications. Although very ill, the turning may be done with care and the benefit derived therefrom.

If atelectasis is present or even suspected, more rigorous treatment should be instituted. Carbon-dioxide and oxygen inhalations are immediately given as one of the most potent treatments. The frequency and depth of respirations produced should depend on the severity of the lesion and the amount of relief obtained. In the administration of carbon-dioxide, the patient should preferably be rebreathed in a closed bag. A closed mask is applied over the nose and mouth to insure sufficient concentration of the carbon-dioxide mixture by eliminating the chance for escape of gas. The average length of rebreathing is from five to ten minutes, and should be given until a depth of respiration is reached at which the patient can no longer voluntarily withold breathing because of pain at the wound site. To promote drainage of the bronchi by placing the patient on his uninvolved side while administering carbon-dioxide is helpful. This is further improved by lowering the head in the Trendelenburg position. In this position, the involved bronchus and lung are in the upper, freely-expanding portion of the chest. Aeration of the lung is encouraged and the plugged bronchus has every opportunity to drain dependently into the

trachea from where the mucus can be expectorated. There is also a possibility of bilateral involvement which should be treated by frequent changes from side to side with inhalations. Frequently, a guarded blow (manual percussion) over the involved portion of the lung, will dislodge a plug, especially when it is in optimal position for dependent drainage. An adjuvant is to support the abdomen manually to aid in coughing.[17] Jacobsen and his co-workers[6] advocate the use of artificial pneumothorax in the treatment of the more extensive cases and have shown good results. The basis of treatment consists of the introduction of positive pressure into the pleural cavity of the involved side, to overcome the increased negative pressure caused by the atelectasis and thereby restore the mediastinal balance. Also, by the introduction of pressure, the bronchus is aided in forcing out the obstructing agent. This type of treatment contests that of bronchoscopic drainage as advocated by Jackson,[11] Overholt et al.,[12] and others who show equally satisfactory results. Both methods of treatment are proficient in expert hands and when done under optimum conditions. Ordinarily, they cannot be used as a routine, and should be reserved for the more severe cases. A concerted effort should be made to relieve the condition by medical means before resorting to an operative procedure.

In place of the hypnotic and more or less vegetative state of a patient that is kept under heavy doses of morphine, the patient should be kept as little suppressed as possible. Considerable relief can be obtained by the careful administration of sedatives and hypnotics without the accompanying marked suppression of respiration. Only morphine will suffice in some cases, but the routine use of opiates in large doses postoperatively should be abandoned. Encouraged deep breathing is advised as a routine. The use of tight dressings and abdominal binders have created considerable comment as to their effect on the patient. A binder will by compres-

sion necessarily diminish the depth of excursion of the diaphragm and lower chest, and consequently diminish aeration of the lung. On the other hand, it will give the patient both a sense of support and also actual support so that he will be more willing to cough and try to expectorate mucus from the bronchi and trachea. An expectorant should be given, either by mouth, or intravenously (as sodium iodide) if the oral route is not practicable. Steam inhalations also aid in loosening secretions. By thinning and thereby loosening secretions in the bronchi, a patient is quite apt to expectorate occluding mucous plugs. Later plugging of the bronchus may sometimes be prevented in patients that have considerable bronchial secretions by giving them postural drainage in the Trendelenburg position for several hours or for shorter periods at intervals. This facilitates drainage of the bronchi and makes it much easier for the patient to expectorate mucus than in the sitting position as is frequently thought.

Routine inhalations of oxygen, unless cyanosis, dyspnea or tachycardia are extreme, should be discouraged. The increased tension of oxygen in the alveoli causes a diminution in both the depth and rapidity of respirations, and thereby would tend to preserve an atelectasis rather than overcome it. The use of nasal oxygen gives the advantage of switching to carbon-dioxide for brief periods with facility. The use of the tent eliminates this possibility because of the inability to add carbon-dioxide to the oxygen mixture in sufficient concentration to give the desired effect without overventilation and possible alkalosis.

In a recent symposium, writers at the Mayo Clinic advocate the use of high concentrations of oxygen routinely in postoperative care, stating that it assists in clearing mucus in the bronchus,[18] and also increases the concentration of oxygen to the atelectatic area, if present, and thereby will help prevent infection and edema.[19] In my experience, relief can usually be obtained by measures directed at re-expanding the collapsed lung tissue, and this is best done by the administration of carbon-dioxide mixture directly in intermittent and concentrated doses; oxygen is not used as a routine. In the minor cases, the simple expedient of rebreathing in a closed sack is worth while, the effect being derived from the accumulation of carbon-dioxide breathed by the patient.

In summarizing the treatment of atelectasis, it might be said that the most important contribution is the knowledge of detecting an early lesion before the plug has engaged in the bronchus and irreversible anatomicopathologic changes have taken place in the collapsed lung tissue. One may be guided in the type of treatment by the apparent severity of the condition. Measures such as frequent changes in position of the patient, diminished use of opiates and encouragement of deep breathing can be used as routine postoperative care, especially in those that are potential cases of atelectasis. If atelectasis is known to be present, more drastic measures such as posturing, carbon-dioxide inhalations or any other attempt to dislodge a bronchial plug and aerate the lung may be instituted. Bronchoscopic drainage or artificial pneumothorax should ordinarily be reserved for the severe, intractable cases unless facilities are optimal for that type of treatment, as is the case in some clinics. Whether the atelectasis is due supposedly to a bronchial plugging or is due to a paralysis of the diaphragm, the treatment should be the same and every effort made to relieve the condition early before further changes can occur.

After the atelectasis has been relieved, an attempt should be made to aid the patient in expectorating the secretions that usually form in the bronchi. The remainder of treatment is supportive. A mild fever may persist for several days as a result of the mild pneumonic congestion associated with the atelectasis.

CASE REPORTS

A résumé of cases that follow, will serve to illustrate some of the less common and less acceptable statements that were made in the foregoing article. Only the pertinent points will be mentioned.

CASE I. This is a case of a middle-aged female, on whom an appendectomy was done for an acute suppurative appendicitis, with drainage. By the time eight hours had elapsed postoperatively, the patient's temperature had risen abruptly to 104.2°C., with an associated exaggerated rise of pulse and respiratory rates. Examination of the lungs revealed only moist rales through both lower lobe bases. There was a slight suppression of breath sounds but they were not completely absent. There was no noticeable heart shift. Cyanosis of a mild degree and some dyspnea were present. More on the suggestion of the temperature, pulse and respiration curves than on physical findings, the patient was given the routine treatment for atelectasis and in the following eight hours, the temperature, pulse and respirations dropped almost to normal and remained there. A subsequent mild fever from a pelvic peritonitis showed very little change in pulse and respiratory rates in marked contrast to the previous response. The extent of the lesion could not be determined but the response to treatment was typical of atelectasis.

CASE II. An elderly male, who was suffering from a quite severe bronchiectasis, had a cholecystectomy done. Every precaution was taken in the preparation of the patient and in the choice of a mild anesthetic. Following operation, the patient was given medicated steam inhalations to promote and loosen bronchial secretions, and carbon-dioxide inhalations were given as a prophylaxis against atelectasis. After two days, the carbon-dioxide inhalations were discontinued because the patient was progressing well. Following this, the temperature rose abruptly to 102°C. with a rise in pulse and respiration. Carbon-dioxide inhalations were resumed following which the temperature again dropped. Upon discontinuing the inhalations, the temperature again rose to about 102°C. Examination of the chest at this time revealed a patchy area of bronchial breathing in addition to the diffuse areas of coarse rales that were present before, and it was believed that the patient had an area of pneumonic consolidation.

This case illustrates the repeated plugging of a bronchus or bronchi from a pre-existing productive state, with probable silent plugging of one of the smaller bronchi and ensuing pneumonia.

CASE III. A young male adult, who was operated upon for an acute catarrhal appendicitis with no drainage, seemed to have a slight bronchitis with cough following operation, so steam inhalations were administered. On the third postoperative day, the doctor was called because the patient was very dyspneic, and had difficulty in breathing. The temperature had shown a sudden rise to 102.4°C., together with a rise in pulse to 130. The patient appeared quite cyanotic. Examination showed numerous rhonchi and further evidence of considerable mucus in the bronchial tree. In addition there was a suppression of breath sounds throughout the middle lobe of the lung and a shifting of the heart apex to the right. The patient was turned on his uninvolved side and upon doing so, felt a sudden choking sensation which was followed by a severe coughing spell from which he expectorated a large amount of mucopurulent material. Even after this, the temperature continued to rise to 104.6°C. Because of the failure of mild treatment previously, the patient was treated more drastically with postural drainage and adequate administration of carbon-dioxide inhalations. Following this, the temperature, pulse and respirations dropped dramatically to near normal and remained there. This illustrates a delayed plugging due to an abundance of mucus in the bronchi, and also the importance of adequate treatment.

CASE IV. A young female, who was operated upon for a suppurative appendicitis, with drainage, developed a mild peritonitis following operation, with intestinal distention and temperature of 100 to 101.4°C. On the fourth postoperative day, the temperature rose abruptly from 100 to 102 4°C., with the pulse and respiration rise typical of atelectasis. Examination of the chest showed a fixing of the left lung base with suppression of breath sounds and dullness to percussion. Occasional atelectatic rales were heard throughout the basilar area. The abdomen showed some generalized distention but most of the distention seemed to be over the stomach area. To relieve the gastric distention, a lavage was done with liberation of a large amount of gas. The patient was turned on the right side and rebreathed with carbon dioxide. Following this, the temperature, pulse and respiration dropped immediately

within the next four hours, and examination of the lung showed remobilization and aeration.

CASE V. This embraces repeated cases of male workers with bronchitis, who developed a low-grade fever following operation with no particular rise of pulse and respirations. Without treatment, the temperature would average between 101 and 102°C. for five to six days and then return to normal by lysis. Examination of the lungs usually revealed a few moist rales at the bases. An expectorant was given to these patients routinely, and it was found that the temperature would drop within the following twenty-four hours in most of the cases, provided they had no other cause for the fever. In view of the bronchitis that was present, and the persisting fever, these cases were considered as those of lobular atelectasis—a manifestation, so to speak, of the bronchitis. One could believe that the fever was caused by the bronchitis, but it seems more probable that the productive bronchitis caused multiple plugging of the bronchioles and ensuing patchy atelectatic areas, which were relieved by the thinning of the secretions and inducement to cough. None of these patients had upper abdominal operations.

CASE VI. This was the case of a middle-aged female, operated upon for an ectopic pregnancy. Following operation, the abdominal wall was quite rigid. The temperature was elevated, and the pulse was ranging from 150 to 160, with respirations between 30 to 40. Examination of the chest showed suppression of breath sounds at the right base, with dullness and lag of the chest wall. The shifting of the heart apex to that side was questionable. Because of the possibility of obtaining some relief, the patient was turned on the left side and carbon-dioxide inhalations repeated at intervals. After several of these, the breath sounds had partially returned to the right lung base, and the pulse had dropped to 120, the respirations to 26. The patient volunteered that she felt much relieved. The temperature remained elevated, however, apparently due to intra-abdominal conditions. This case illustrates the relief obtained by improving lung physiology simply by aeration.

SUMMARY

1. Atelectasis has been definitely established as being one of the commoner of postoperative complications. When one considers the immediate postoperative pulmonary complications, it apparently is the most important and most frequent condition encountered.

2. Atelectasis may follow a plugging of one or more of the bronchi or bronchioles, or may be caused directly by compression from adjacent structures with occasional secondary plugging by mucus forming from hypersecretion of the immobilized lung tissue.

3. Atelectasis may be classified as lobular, lobar or multilobar, depending on the extent of involvement, the latter two being classed as massive atelectasis in place of the misleading term, massive collapse.

4. A sudden elevation of temperature in the first twenty-four hours of the postoperative period, together with an exaggerated rise in pulse and respiration, should immediately suggest atelectasis, and steps should be taken to establish the diagnosis.

5. Because of the frequency of atelectasis following upper abdominal surgery, and following inhalation anesthesia on patients with productive processes in the lungs, these should be considered as potential cases and postoperative prophylactic measures be instituted immediately.

6. Treatment consists of thinning the bronchial secretions, assisting in expectoration by posturing, coughing, etc., and re-expansion of the collapsed lung by promoting deep respirations.

7. In addition to the typical massive atelectasis, there are minor lobular involvements which show no typical picture but do produce a postoperative morbidity.

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THE MANAGEMENT OF ACUTE EMPYEMA IN CHILDREN*

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THE standardization of the treatment of any surgical condition will be effective only if certain principles are constantly borne in mind. If any standardized form of treatment is applied to every case of a disease whose course depends on so many variable factors as does empyema, poor results will inevitably follow.

The important variable factors in acute empyema are: the age of the patient, the virulence of the infecting organism and the stage of the causative initial disease—pneumonia—at the time the complicating empyema develops. It is pertinent here to stress the fact that statistical evidence of the merits of any one method of treatment of empyema is of little value unless a sufficiently large number of cases are considered, and particularly unless there has elapsed a long enough period of time during which that treatment has been used. The incidence of empyema varies greatly from year to year, as does the virulence of the strain of the predominant infecting organism.

It is too soon to state with assurance what the influence of chemotherapy on the incidence of empyema will be. There appears, however, to be a very hopeful lessening of this complication of pneumonia especially if adequate chemotherapy has been used at the onset of the pneumonia.

We can, however, report encouraging figures in the treatment of this complication of pneumonia. From 1919 through 1938 there were 467 cases of empyema treated at the Children's Hospital. Only six of these patients received chemotherapy. Those receiving chemotherapy since January 1, 1939, will be discussed later. Table 1* shows the comparative figures for the four five-year periods, and also the figures for the patients under two years of age. The gratifying drop in mortality in the last five-year period may possibly in some degree have been due to a lesser virulence of the organisms during those five years. The greater credit, however, must go to a more efficient handling of each case. A sufficiently large number of cases over a five-year period should minimize the factor of a lesser virulence of the organism from year to year. Such is not the case in a series reported for a single year. (Table 1.)

TABLE 1

RESULTS OF TREATMENT OF 467 CASES OF EMPYEMA IN CHILDREN JANUARY 1919 TO JANUARY 1939 BEORE CHEMOTHERAPY

Five-Year Period	All Cases			Patients Two Years or Under		
	No. of Cases	No. of Deaths	Mortality Per Cent	No. of Cases	No. of Deaths	Mortality Per Cent
1919–1924	94	13	14	20	7	35
1924–1929	86	11	13	21	7	33
1929–1934	150	20	13	57	12	21
1934–1939	137	3	2	46	2	4

To apply indiscriminately one form of treatment to every case of empyema regardless of the stage of the disease, the infecting organism and the age of the patient is to invite disaster. Each case must be treated as the requirements of the individual case indicate. It is to be emphasized particularly that empyema is a complication of pneumonia and must so be regarded. Empyema itself is seldom the

*Lanman and Heyl. Empyema in Children. *New England J. M.*, 221: 1003–1007, 1939.

cause of death; it is seldom a surgical emergency. Patients die with empyema rather than because of it.

In our series just referred to the predominant organism was the pneumococcus in 80 per cent, the streptococcus and staphylococcus in about 10 per cent each, and other organisms less than 1 per cent. The cases of streptococcal infection, while small in number, had a mortality of 33 per cent, the staphylococcal group 11 per cent and the pneumococcal group about 3 per cent.

FORMS OF TREATMENT

In general there are three forms of treatment: aspiration, intercostal closed drainage and open thoracotomy with or without rib resection. It cannot be emphasized too strongly that each of these has its sphere of usefulness, its limitations and its contraindications. No one of these three or even a combination of one or two can or should be routinely used. Each case must be treated by a method or combination of methods suitable for that particular case.

Aspiration. This form of treatment is most useful in the early stages of empyema. At this time the fluid is thin, whatever the infecting organism. Aspiration establishes the diagnosis and permits identification of the organism. It is the method of choice particularly during the stage of active pneumonia. Unless the fluid is large enough in amount to give mechanical embarrassment to the patient as shown by displacement of the heart, little more than a diagnostic tap need usually be done. The presence of pleural effusion at this stage of the disease, if it is not causing mechanical embarrassment, is of relatively slight importance to the welfare of the patient. It is only one manifestation of the pneumonia. With proper infiltration of the skin by novocain, withdrawal of this thin fluid can be done with a minimum of discomfort and without moving the patient from bed. Aspiration, then, in addition to identifying the organism, provides an easy and non-shocking method of relieving the mechan-

ical embarrassment caused by a pleural effusion particularly in those patients who are still critically ill with pneumonia.

Intercostal Closed Drainage. This is most useful in cases in which the accumulation of fluid is so great and so rapid that frequent tapping fails to give adequate relief of the mechanical embarrassment caused by the fluid. By providing continuous drainage it obviates the discomforts, small as they may be, of repeated aspiration. The procedure may be done with little less added pain and without moving the patient from bed. Often, particularly in cases caused by the streptococcus, it results in cure.

The simpler the technic used the better if certain principles are observed. We use a soft rubber catheter which is inserted through a cannula. A small area in the skin and the chest wall muscles is infiltrated with novocain. If a small incision is made in the anethetized skin with a knife, it lessens the discomfort of passing the trochar and cannula into the pleural cavity. The catheter should fit the wound snugly after the cannula has been withdrawn. The usual precautions of not allowing air to enter the pleural cavity should be observed, and the catheter should extend only a short distance, one to two inches, within the pleural cavity. After removal of the fluid, and this should not be done too rapidly, the catheter is connected with another length of rubber tubing, the distal end of which is placed under water in a container at a lower level than that of the patient's chest.

Dependent drainage is a well recognized surgical principle but it must be remembered that if there is a large pleural effusion the diaphragm is often pushed down. In such a case, if intercostal drainage is established at the most "dependent" interspace, say the ninth, the diaphragm rises as the fluid drains off and may often press the catheter against the chest wall and so interfere with adequate drainage. The seventh interspace is usually the interspace of choice for intercostal drainage. In

cases that have had intercostal drainage and later require rib resection it is important to realize that the diaphragm may be higher than at the time of the intercostal drainage. The rib above the site of intercostal drainage should always be used. This gives better drainage and will obviate the chance of inadvertently going through the diaphragm. For intercostal and for rib resection drainage, the posterior axillary line is the site of choice in the great majority of cases.

There has been a great deal of discussion about "airtight" closed drainage, tidal irrigation and so forth in the treatment of empyema. We are convinced after thorough trial that attempts to maintain "airtight" drainage by elaborate mechanical means are ineffectual after a few days. While it is desirable to have closed drainage in a sick patient, we believe there is no form of apparatus that will stay "airtight" for more than a week or two. Also the necessity for airtight drainage for a longer period than two weeks is seldom if ever sufficiently important to be of any consequence.

Tidal irrigation and similar complicated forms of drainage have been abandoned here. The simpler the form of apparatus the better. As far as irrigation is concerned, attention is directed toward preventing the catheter from becoming clogged.

If, after a week or two, particularly in the pneumococcal infections, the intercostal drainage tube is not providing adequate drainage, the condition of the patient should by that time be sufficiently improved to warrant open surgical drainage. As we have stated previously the value of intercostal closed drainage is particularly great in early cases and in young patients. Much of the condemnation of drainage by rib resection has been wrongly attributed to the operation rather than to the choice of case in which it was used. Primary open operation with or without rib resection should never be employed during the synpneumonic stage regardless of the age of the patient and

seldom if ever should it be employed for patients under two years of age. It is to be noted that "primary" open operation means open operation *not* preceded by some form of closed drainage. We wish, however, to emphasize that in many cases too long continued attempts to obtain adequate drainage by closed methods should be abandoned and open drainage substituted. Enough patients have come to the Children's Hospital with chronic empyema after weeks and even months of inadequate drainage of the pleural cavity by intercostal tube to convince us that such drainage should not be prolonged much over two or three weeks unless there is obvious evidence of improvement as shown by the clinical condition; decrease in the size of the cavity and re-expansion of the involved lung. The patient whose general condition has not improved sufficiently to warrant open drainage after two or three weeks of closed drainage is a rarity, and in such cases there is usually some other complicating factor, frequently a bronchopleural fistula.

Open Drainage. In properly selected cases this is an efficient and safe form of treatment. Its chief danger is the unwise selection of cases for its use particularly as regards the stage of the disease when drainage is instituted, and the age and general condition of the patient. In private practice the usefulness of this method is limited largely to cases that have not responded well to intercostal drainage. It is important to use this method of more efficient open drainage in such cases, however, to minimize the chances of a chronic empyema. Each case must be judged carefully on its merits. If after two or three weeks of intercostal drainage there is not a satisfactory improvement, adequate open drainage should not be unduly postponed. This is particularly true in the pneumococcal infections.

Primary rib resection is seldom if ever employed in private practice or in cases under observation on the wards from the onset of the pneumonia. Paradoxically,

however, in our series the large group of patients on the wards who received a primary rib resection did much better and had a shorter hospital stay than did those receiving other forms of drainage. In the past ten years 168 patients out of 287 received a primary rib resection. The average duration of postoperative drainage for this group was twenty-four days; all ended in complete recovery. The average duration of postoperative drainage was forty days for the group treated by intercostal drainage, and fifty-seven days for the group receiving intercostal drainage followed by rib resection.

The reason is obvious. This large group of patients was referred to the hospital when they were well over their pneumonia, if indeed the pneumonia had been recognized. The child often gave a history of a "cold" with "congestion of the lungs." He was confined to bed for a period of time. The fever subsided after a week or so and re-appeared a few days later. He received little or no treatment for his pneumonia, but because of failure of early diagnosis of fluid in the chest, the necessity for surgery was realized at more nearly an optimum time than is true of patients in a better economic status. This sort of medical treatment of pneumonia is certainly not advocated. It confirms the opinion, however, that the surgical treatment of acute empyema is seldom a surgical emergency.

There was only one death in the last five years following primary rib resection and that was in a child one year of age. Our rule is now to do no primary rib resection in a patient under two years of age. All primary rib resections are preceded by a diagnostic tap. The usefulness and indication for primary rib resection are limited largely to the class of patients in the economic bracket referred to above. It is seldom if ever to be advocated in private practice. Rib resection is, however, to be used in cases that do not do well with intercostal drainage and it often is not only useful but necessary, particularly in the pneumococcal cases.

TECHNIC OF RIB RESECTION

Here again simplicity is desirable. While the site of drainage depends on the location of the pus, the posterior axillary line is the usual site and the seventh rib the usual and best location for the resection. About one to two inches of the rib are resected subperiosteally and a double flanged empyema button inserted. The lung should be freed, as free respiratory movements promote drainage, and re-expansion of the lung obliterates the cavity. Reasonable activity by the child as well as the use of blow bottles favor re-expansion of the lung. We allow and encourage them to be up and about as soon as the fever subsides. The button is seldom left in place for more than two weeks.

Scoliosis. It is our firm belief that permanent structural scoliosis will seldom if ever result if the empyema cavity is properly drained. Proper drainage will result in obliteration of the cavity with complete re-expansion of the lung. Postoperative x-rays taken during convalescence before the cavity had been obliterated often show some scoliosis. But at this time efforts should be directed towards favoring drainage and re-expansion of the lung, and the child should be encouraged to be as active as his condition warrants. Once the lung is well expanded and the cavity obliterated, the scoliosis will disappear. During convalescence methods directed toward the treatment of the apparent scoliosis *per se* are, in our opinion, contraindicated. Immobilization of the child on a Bradford frame, or some other form of apparatus, in order to treat the scoliosis will at this time hinder and may even defeat nature's successful efforts to overcome what is usually a functional and not a true structural scoliosis. Methods that aid nature in the obliteration of the cavity and re-expansion of the lung are the best methods of overcoming or preventing a scoliosis.

Anesthesia. Local novocain infiltration gives satisfactory anesthesia for aspiration and for most cases of intercostal closed drainage. Occasionally, a very brief general anesthesia is desirable for intercostal drainage. Nitrous oxide and oxygen if properly given is safe and satisfactory; cyclopropane is very useful but has the added risks inherent in its explosive nature. I still believe that ether and oxygen is at times superior to nitrous oxide and oxygen, and for a brief anasthesia we do not hesitate to use it in a chest case if we believe the anoxemia of even a short nitrous oxide administration is undesirable.

There is one general rule, however, that is most important. The patient whose condition does not warrant the use of a general anesthetic is the patient who at that time should not be submitted to those more radical forms of drainage for which general anesthesia is required and desirable.

Chronic Empyema. The best form of treatment of chronic empyema is its prevention by adequate treatment during the acute stage. The incidence of chronic empyema in cases under observation from the start at this hospital is as gratifyingly low as is the present low mortality rate. The treatment of chronic empyema is not within the scope of this paper. It, like chronic lung suppuration with which it is often associated, is a special problem.

Chemotherapy. As stated earlier, any definite conclusions on the usefulness of chemotherapy in the treatment of empyema cannot be made as yet. A very few patients with streptococcal empyema received sulfanilamide during 1938 which was the last year covered by the report from which statistical data have been quoted in this article. From January 1939 to June 1941 (two and one-half years) there have been forty-five cases of empyema treated at this hospital. If the same number enter in the next two and one-half year period, it will make a total of ninety cases for the first five-year period covering the use of chemotherapy. The two previous five-year periods gave an incidence of 150

and 137 cases, respectively. It is difficult to say whether this present number represents a true drop in the incidence of empyema because the incidence of empyema itself varies so much from year to year. We believe it is undoubtedly significant, however, that since 1939 of all the patients with acute pneumonia who entered the hospital and received chemotherapy, not one developed empyema. The patients with empyema treated here during the past two and one-half years entered the hospital with the empyema already developed. Some of these had had chemotherapy at home.

Our impression here is that sulfathiozole is superior to sulfanilamide even in streptococcal cases. Sulfathiozole seems superior to sulphapyridine in the pneumococcal cases. In recent months sulfadiazine seems superior to any of the sulfa compounds yet used and appears to have far less danger or cause less renal injury than sulfathiozole or sulphapyridine. Patients receiving chemotherapy demand careful observation with frequent estimation of the blood level of the drug, and particularly daily urinalysis to determine any evidence of kidney damage. Patients who have developed empyema under chemotherapy probably did not have the drug used early enough or in adequate dosage during the pneumonia, though this statement is not yet proved.

Treatment of an empyema that occurs following chemotherapy is worth discussion. It is probably of little use to continue chemotherapy once the empyema has been drained unless the pneumonic process itself is still active. A greater per cent of the patients with pneumococcal empyema who have had chemotherapy seem to require radical open drainage sooner in the course of the disease than did those in the past who did not have any chemotherapy. The exudate on the pleura is likely to be thicker and more tenacious and it is very difficult to clear up such a case by the closed methods. Although the number of cases is not large this has been a striking finding. It has been necessary to take greater pains actually to free with the finger the thick

tenacious exudate that lines the empyema cavity of such cases.

While it may be premature to say so, one gets the impression that if chemotherapy is properly used from the onset of the pneumonia, the incidence of a complicating empyema will be very slight. On the other hand if chemotherapy is not adequate in amount or is not started until late in the pneumonia, it is not yet possible to say that the use of this drug will lower the incidence of a complicating empyema. It is possible to say, although time may refute the statement, that cases receiving inadequate chemotherapy that do develop empyema, are more difficult to clear up. Our experience seems to indicate that open drainage will be used in a greater percentage of these cases than was the case before chemotherapy, but again we wish to emphasize that open drainage should not and need not be done as a primary procedure in patients still in the toxic stage of pneumonia.

CONCLUSIONS

The drop in the mortality statistics at this hospital before the event of chemotherapy justifies certain conclusions. Acute empyema should never be regarded as a surgical emergency. The condition in the pleural cavity should be treated as a complication of a general systemic infection. Children, especially infants, die with empyema and not because of it. The infecting organism should be determined in all cases by a diagnostic thoracentesis. The indication of each individual case must determine the proper type of drainage for that case. Local anasthesia for aspiration and intercostal closed drainage is indicated in almost all cases. Open drainage with or without rib resection is advocated in cases that do not respond after a period of time to closed methods of drainage. If the patient's condition contraindicates a general anesthetic, methods of drainage requiring general anesthesia are also contraindicated. Primary open drainage, with or without rib resection, should never be done during the synpneumonic stage or in children under two years of age. In properly selected cases primary rib resection is a safe and efficient method of treatment. If the empyema cavity is well drained and obliterated by the re-expansion of the lung, scoliosis need not be feared. It seems probable that the efficient use of chemotherapy will greatly lessen the incidence of a complicating empyema. While not yet proved, it would seem that if the empyema developed in patients receiving chemotherapy, its treatment required the more frequent and earlier use of open surgical drainage. It is likely that such cases did not have adequate dosage of the drug at the onset of the pneumonia.

ETIOLOGY OF CHRONIC EMPYEMA

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A PROPER understanding of the pathology and pathological physiology of acute empyema, and the application of these facts to the treatment of the disease would render chronic, nontuberculous empyema a clinical rarity. The findings of the Empyema Commission of the First World War are as valid today as they were in 1918; the facts have been emphasized in many publications, and yet we find daily instances in which these principles have been violated with disastrous results to the patient. It can be stated flatly that improper handling of acute empyemas is responsible for most cases of chronic empyema. There are some cases apparently doomed to chronicity from the onset, because of conditions which will be discussed later but these are a small percentage of the total. The incidence of chronic tuberculous empyema can be appreciably lowered, as the discussion will bring out. Since it can be seen that prophylaxis is of the utmost importance in the problem of chronic empyema, we believe it necessary to review the salient features of the pathology and treatment of the acute disease.

Empyema is the result of pleural reaction to infection, the extent and severity of the reaction varying with the infecting organism. In many cases of pneumococcic pneumonia it is probable that fluid is present in the pleural cavity before the crisis. Usually the amount of fluid is slight and the organization of fibrin produces agglutination of the pleural surfaces with subsidence of the pleural infection. If the process progresses and pus is formed, the abscess develops within the fibrinous deposit and may be large or small depending upon the amount of fluid and the presence or absence of limiting adhesions.

The route by which infection gains access to the pleural cavity has been variously discussed but the generally accepted opinion is that empyema develops as the result of the rupture of a small subpleural pulmonary abscess into the pleural cavity. Empyemas resulting from trauma to the chest and by extension from a subdiaphragmatic abscess are rare enough so that they may be disregarded as far as the purposes of this paper are concerned. Clinically, pneumococcic empyema develops after the pulmonary process has subsided. As a result the patient is suffering only from the effects of a localized, intrapleural abscess. In most cases fibrinous adhesions have formed between the previously involved lobe and the overlying parietal pleura. Along with this process fibrin has been deposited over the mediastinum, rendering it, as the fibrin organizes, a rigid septum between the two pleural cavities.

The pathological physiology of streptococcic empyema is quite different from that of pneumococcic. In the recognition of the difference and the effect this difference has upon treatment lies the secret of success in empyema. While in pneumococcic empyema the preceding pneumonia has usually subsided, in the streptococcic type the two conditions are concomitant. As a result the patient is much sicker and the mortality higher. It is believed that in streptococcic empyema the organisms spread through the interstitial pulmonary tissues to the pleura, producing a diffuse, abundant exudate. Because of the rapidity with which fluid develops and the comparatively low fibrin content of the fluid, limiting adhesions are unusual. Similarly, mediastinal stiffening does not occur.

As a result of the fundamental work of Graham and Bell certain facts of the utmost importance, particularly in regard to the effects of open pneumothorax, were brought to the attention of the profession.

They particularly emphasized that in the presence of a pneumothorax both lungs are affected nearly to the same extent. The loss of pulmonary function depends on the size of the pneumothorax opening. Of greatest importance is the relation of the size of the opening to the vital capacity. The greater the vital capacity the larger the opening tolerated. With a low vital capacity, approaching the point at which the maximum inspiratory effort only supplies tidal air requirements, a small pneumothorax opening may prove fatal. The above conclusions all suppose a thorax without adhesions or inflammatory change. In the presence of adhesions or a rigid mediastinum, as in chronic empyema, the normal pressure relationships no longer hold and the pressures in the pleural cavities may be changed independently. Therefore, large pneumothorax openings are well tolerated if adhesions or a rigid mediastinum are present.

The intelligent application of the fundamental facts of pathology and physiology, as noted above, are essential in the treatment of empyema so that mortality will be lowered and chronicity reduced to an unavoidable minimum. The methods commonly employed in the treatment of empyema, with many individual variations of technic, are aspiration, closed drainage and open drainage. The particular technic employed is unimportant, the attention to principles all important.

It has been said that in pneumococcic empyema the pulmonary lesion has usually subsided by the time the empyema becomes clinically evident. The pus is thick, adhesions are present and the mediastinum is rigid and indurated. In these cases open drainage is the treatment of choice. The establishment of an open pneumothorax offers little hazard to the patient since the vital capacity has not been lowered to dangerous levels and the rigid mediastinum prevents the altered pressure in the affected hemithorax from being transmitted to the uninvolved lung. We do not believe it essential that drainage be established at the most dependent portion of the empy-

ema cavity. Attempts to reach the most dependent portion may result in damage to the diaphragm and the danger of peritonitis. Also, it has been found that rise of the diaphragm as the cavity becomes smaller may interfere with drainage. It is sufficient that drainage be established near or below the center of the cavity. Since an expanding lung increases in size concentrically, drainage in this area will be efficient.

As opposed to the treatment of pneumococcic empyema, open drainage should never be used in the course of a streptococcic empyema. An open pneumothorax must be avoided in these patients who are acutely ill, toxic and with greatly reduced vital capacities. The object of whatever method is chosen is to tide the patient over the period of acute pneumonia and to wait until intrapleural adhesions and a rigid mediastinum have formed, at which point open drainage may be established. This may be accomplished by either repeated aspirations or continuous closed drainage. The optimum time at which to institute open drainage will be determined by a fall in temperature, reduction in toxicity, relief of dyspnea and cyanosis and a change in the character of the pleural exudate from a thin, watery greenish material to a thick, creamy pus. If aspirations have been used, it is important that they be discontinued at this point, since lack of adequate drainage may cause great thickening of the visceral pleura, an unexpandable lung and a resultant chronic empyema.

The other commonly employed method of emergency treatment in streptococcic empyema is continuous closed drainage. This may be supplemented by some form of suction or tidal drainage depending on individual preferences. Both have had their enthusiastic advocates. It is doubtful if any form of closed drainage has much advantage over repeated aspirations followed by open drainage. It is very difficult to keep a closed system air-tight and the nursing care involved is a definite problem in the average hospital. It is our belief that the

chief value of closed drainage is as a substitute for aspirations in an extremely sick patient, provided that at the opportune moment open drainage be established.

It is apparent from the preceding remarks that chronic empyema will result most often from lack of attention to principles of treatment. Most important in the prevention of chronicity is adequate drainage, carried out at the proper time and continued until the cavity is obliterated. Drainage delayed until fibrin has organized and covered the visceral pleura with a thick, tough layer will prevent expansion of the lung and make for chronicity. Also, premature removal of drainage material before the cavity is obliterated will permit superficial healing of the drainage tract and maintenance of a residual pocket of empyema. It is in this type of case that we see the so-called recurrent empyemas which are, in reality, not recurrent since the initial empyema was never cured.

In attempting obliteration of an empyema cavity sterilization of the contents and liquefaction of the fibrinous exudate over the lung are essential. One of the most efficacious measures we possess to carry this out is Dakin's solution. Frequent irrigations with this material should be used in all cases in which there is no demonstrable bronchopleural fistula. Since many small bronchopleural fistulae close spontaneously as the empyema cavity closes, Dakin's solution may be cautiously re-employed at intervals if a fistula has necessitated its temporary discontinuance. All empyema cavities should be carefully measured and frequently examined roentgenologically, employing a contrast medium such as lipiodol, if indicated. Only when the capacity of a cavity is a half ounce or less should drainage be removed.

In addition to the factors of improper, delayed or insufficient drainage as causes of chronicity, the causes usually given are tuberculosis, persistent bronchopleural fistula, underlying lung abscess, intrapleural foreign bodies, osteomyelitis of ribs and underlying carcinoma of the lung. Butler

has reported several cases in which another predisposing cause of chronicity may play a part, namely, postpneumonic atelectasis. Hochberg has recently reported two cases in which this mechanism seemed to play an important rôle.

Tuberculous empyema is a chronic disease; its most effective treatment is prevention. We believe that the incidence of tuberculous empyema can be materially reduced. It is known that the percentage of effectiveness of pneumothorax decreases in direct proportion to the time taken for the pneumothorax to become effective. It is also a fact that the majority of cases of tuberculous empyema follow as a complication of pneumothorax. More empyemas develop in ineffective pneumothoraces than in effective ones. Therefore, if ineffective pneumothoraces were either abandoned promptly or abandoned as soon as section of adhesions by closed, internal pneumonolysis was found impossible, the number of cases of tuberculous empyema would rapidly drop.

Persistent bronchopleural fistula as a cause of chronicity can be avoided in some cases by proper drainage. Delay in instituting drainage is responsible for a few persistent fistulae. However, many of these cases fall into the category of inevitable chronicity. Prompt recognition and treatment of pulmonary abscesses will eliminate many cases of chronic empyema resulting from neglect of this condition. It is our belief that in large lung abscesses, involving a large portion of a lobe, lobectomy rather than drainage will be the treatment of the future.

Foreign bodies retained in the pleura are usually either pieces of rubber tubing or gauze. That these are preventable requires no argument.

Osteomyelitis of ribs is mentioned in every series of cases of chronic empyema. While it occasionally occurs as a cause of chronicity, we believe that more often it results from chronicity and that there are other factors accountable which might be found if carefully searched for, not only

in the chest at the time of operation but also in the history of the original treatment.

The prevention of chronic empyema due to carcinoma of the lung lies of course in early diagnosis and treatment of this increasingly prevalent tumor.

The interesting conception of Butler, previously mentioned deserves some attention. In the four cases reported by this observer and the two mentioned by Hochberg, delayed closure of an empyema pocket and an unusually stormy course seemed directly related to bronchial obstruction and atelectasis. If this condition is suspected roentgenography, pneumonography and bronchoscopy should be done. Dramatic improvement and avoidance of chronicity may be expected if the bronchial obstruction is relieved. Butler believes that even partial relief of the obstruction may allow complete aeration. This is based on the work of Van Allen and Jung who demonstrated that collateral respiration may take place in a lobe in the presence of obstruction of some of the smaller bronchi due to the openings in the interlobular septa and alveoli.

Since we have been interested in the prevention of chronic empyema we have reviewed the last fifty cases of this condition admitted to the Jefferson Hospital. Of these, eight were tuberculous and may be eliminated from the analysis. In many of the cases, most of whom had had their original treatments elsewhere, the histories of the initial illness were not available and conclusions could be drawn only by inference. In ten of the cases the condition could be specifically traced to improper, neglected or insufficient drainage. In fifteen, although the data were incomplete, the histories were highly suggestive of the same factors. Excluding the tuberculous cases it will be seen that 60 per cent of the chronic, nontuberculous empyemas were attributable to the neglect of the fundamental principles of treatment of acute empyema. In twelve of the cases bronchial

fistulae were given as the cause of chronicity. However, since it is likely that most cases of empyema have bronchial fistulae some time during the course of the disease and that most of these close spontaneously with proper treatment, it seems reasonable to predicate that in at least a few of this group the persistent fistulae were an expression of improper treatment rather than a primary cause of chronicity. Two cases were due to foreign bodies and three were attributed to osteomyelitis of ribs. We have previously stated our opinions upon these subjects.

SUMMARY

The fundamental features of the pathology and physiology of acute empyema have been reviewed.

The application of these principles in the treatment of acute empyema have been noted.

The factors leading to the development of chronic empyema have been explained.

Fifty cases of chronic empyema have been analyzed, particularly as to etiology.

CONCLUSIONS

1. Application of the fundamental principles of pathological physiology is essential in the treatment of acute empyema if chronic empyema is to be avoided.

2. Neglect of these principles is responsible for the majority of cases of chronic empyema.

3. This was borne out by an analysis of fifty cases of chronic empyema from the Jefferson Hospital.

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ENCAPSULATED EMPYEMA

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ANY collection of pus within the pleural space, which does not occupy the whole space, can be regarded as a localized empyema in the broadest meaning of the term. For clinical purposes, however, the terms, "localized" or "encapsulated" or "sacculated" are generally applied to smaller collections of pus that are completely sealed off from adjacent uninvolved pleura. It appears to us that special consideration of the localized or encapsulated empyemas is warranted because (1) the pathogenesis, evolution and clinical features often are different from those of total or diffuse empyema; (2) the roentgenographic features are different and problems in roentgenographic diagnosis arise which do not exist ordinarily in total empyema; (3) there are special problems connected with exploratory thoracocentesis; and (4) the surgical management often requires a distinctive approach. Before proceeding with the discussion of these four aspects of the subject, it should ·be stated that very large, so-called subtotal empyemas usually resemble total empyemas so closely that they will not be considered. However, it may not be amiss to point out that the uninvolved pleural space may become infected at operation even in such cases, if certain principles to be set forth concerning diagnosis and surgical management are not observed.

PATHOGENESIS, EVOLUTION AND CLINICAL FEATURES

The question of the pathogenesis, evolution and clinical features of localized empyema should be considered first because of distinctive features which we believe to exist in comparison with those of total or diffuse empyema. At the present time it is generally recognized that the cause of suppurative pleuritis in a sub-stantial proportion of cases is an underlying suppurative pulmonary focus. The latter is unequivocally proved to be present in cases of pyopneumothorax. In cases of empyema the existence of a causative pulmonary abscess may be established at operation, in the postoperative course, at secondary operations, etc. Thus, the absence of air (fluid level) in a case of localized empyema does not negate a causative suppurative pulmonary focus. This point warrants emphasis because a study of our cases of localized empyema discloses the fact that the vast majority are due to suppurative pulmonary foci, usually perforated pulmonary abscesses. This held whether or not roentgenograms revealed the existence of a pyopneumothorax and regardless of the presence or absence of a perforated pulmonary focus at the time of operation. By way of contrast it can be said that the majority of cases of total and diffuse empyemas are not due to demonstrable suppurative pulmonary foci. Another feature which distinguishes the two lesions is the extent of the pulmonary abscess. When present in cases of diffuse empyema, it is usually small and insignificant and apparently an incidental part of a more or less widespread pneumonic lesion. On the other hand, the pulmonary focus is a substantial localized abscess in not a small proportion of cases of encapsulated empyema. Indeed, the causative pulmonary abscess may be larger and more significant clinically than the pleural empyema. Finally, there are instances of encapsulated empyema, such as occasional cases of ruptured interlobar abscess (so-called interlobar empyema), in which involvement of the pleura is so limited that its existence can only be recognized if specially sought for.

From the foregoing remarks on pathogenesis as well as from a consideration of

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the limited extent of pleural involvement in many cases, one can anticipate that the evolution of localized empyema would often be much more insidious and much less obvious than that of diffuse and total empyema. Indeed, the existence of the lesion is scarcely to be suspected in a substantial proportion of cases until revealed by roentgenograms. The symptomatology of encapsulated empyema is in keeping. In some instances the symptoms are essentially those of the underlying abscess whether putrid (anaerobic) or aerobic. Invasion of the pleura is initiated in such cases by a sudden access of localized thoracic pain and may be characterized (by no means invariably, however), by reduction in cough and purulent expectoration. When symptoms of pulmonary abscess do not exist, the course usually is that of an acute pneumonic lesion in the initial phase, followed by low grade fever. Only rarely are there seen the evidence of respiratory distress, cardiac embarrassment or toxemia as often noted in diffuse empyema. This statement applies to children as well as to adults. Indeed, the patient may be up and about for a long time (weeks or even months) before the encapsulated empyema is discovered. A number of our cases first came under observation so long after the acute pulmonary episode that pulmonary neoplasm and not localized empyema was the first diagnosis made on the basis of a well delimited shadow in the roentgenogram.

It is evident that both the physical features and the symptomatology of encapsulated empyemas usually are less simple and clear than those of diffuse empyemas. Indeed, an encapsulated empyema can be defined as a lesion characterized by atypical manifestations. Several features of encapsulated empyema warrant special mention. First, the empyemas which may have little or no parietal contact should be mentioned particularly because of difficulties encountered in diagnosis and of danger of infecting the free pleural cavity by exploratory aspiration or at operation. There are three groups of such cases: The interlobar (which we have shown to be perforated pulmonary abscesses[1,2]) the infrapulmonary and the paramediastinal. At times empyemas in other situations also may present limited contact with the chest wall, apparently because firm parietal adhesions over a small area lead instead to indentation of the lung by the collection of pus. Another feature of localized empyema worthy of special mention is multilocularity. Two or more intercommunicating loculations are common. In some instances loculations appear far removed from one another, but intercommunication by more or less narrow pathways is the rule. Localized pleural invasion as the result of the perforation of a pulmonary abscess of substantial proportions requires discussion because of the problems in diagnosis and surgical treatment which are raised. The symptoms and diagnosis of pulmonary abscess cannot here be described. For our present purposes it will suffice to say that a pulmonary abscess is characterized by the expectoration of pus. Apparently there is a general impression that the perforation of a pulmonary abscess into the pleura is signalized by the cessation of purulent expectoration. Associated with this impression is a belief that the perforation is likely to result in cure of the abscess. Evidence has been advanced elsewhere to show that neither view is tenable.[3,4] Spontaneous cure can follow perforation and expectoration of pus may cease after perforation, but neither phenomenon can be anticipated with any assurance in cases of perforations of substantial abscesses into localized spaces. Thus, the absence of perforation cannot be postulated if expectoration of pus continues and the assumption of cure of the abscess is not warranted because perforation has occurred. The differentiation between the presence and absence of perforation, obviously important for clinical reasons, must be made chiefly by radiological examination as will be shown.

Another feature of encapsulated empyema is the frequent occurrence of adjacent bland pleural effusions, so-called sympathetic effusions. When such effusions encountered by exploratory aspiration present evidences of infection, they may be mistaken for the underlying localized collection of pus. The recognition of their existence in cases of encapsulated empyema is therefore of importance. Finally, reference should be made to a more or less chronic, localized empyema which masquerades as "thickened pleura." This lesion, characterized by fever, dullness to circumscribed flatness on percussion, usually distant breath sounds and a roentgen film of localized density is now generally recognized as an encapsulated empyema. In fact, the pleurae usually are greatly thickened and the collection of pus may be small. Not so generally known is the fact that this type of lesion may follow a variety of intrathoracic operations. Indeed, it may be encountered after operations for nonsuppurative lesions, presumably as the result of unrecognized infection or infection of retained blood. Of particular importance is the variety which may be termed a residue after a more widespread pleural infection has been drained. In such cases the patients may appear to be essentially well for months or even years, complaining only occasionally of episodes of thoracic discomfort or pain and slight transient fever. The roentgen films, however, will always disclose the appearance of "thickened pleura" even during the periods of complete well being.

ROENTGENOGRAPHIC FEATURES AND DIAGNOSIS

A quantity of pus in the pleural cavity casts a dense homogeneous x-ray shadow. While the boundaries of total or subtotal empyema are obscured on the films, at least one boundary will be clearly defined in the case of encapsulated empyema. If a pneumonic shadow exists, the collection of pus usually casts a homogeneous shadow which is denser and which usually has at least one well defined margin. The shadow of an encapsulated empyema is usually semi-ovoid in shape with the base against the chest wall. The inner margin may be straight, convex mesially or scalloped if the collection is in the axilla. If situated at the anterior or posterior chest wall, only lateral or oblique views will demonstrate limits of loculation. A homogeneous density over pneumonic lung which lacks more or less clearly defined margins distinct from those of pneumonitis is probably due to plastic pleural exudate. Only re-examination can determine if pleural pus with loculation will supervene. The variations of these fundamental roentgen features will be discussed under the separate caption devoted to special varieties.

Throughout the discussion the terms encapsulated or circumscribed empyema and encapsulated or circumscribed pyopneumonothorax will be employed interchangeably. The reason is to be found in the fact that from the viewpoint of roentgenology a fluid level is in the nature of an accident. Its presence is indubitable evidence of a perforated bronchogenic pulmonary abscess. The absence of a fluid level does not exclude the existence of a perforated abscess. The absence of air in the empyema may mean nothing more than the absence of a free bronchial communication at the time of perforation of the abscess. Attention has already been directed to the frequency of perforated pulmonary abscess as the cause of encapsulated empyema. We may add here that, in not a few instances, the existence of the perforated pulmonary focus is to be noted for the first time at operation (or after operation by the discovery of a bronchial fistula), because preoperative films failed to reveal fluid levels or air pockets within the shadows of encapsulated empyemas.

As already indicated the diagnosis of an encapsulated empyema must be based chiefly on the roentgenological examination. Of physical signs the most important is localized dullness or flatness on precussion, an abnormality which is better

identified by the sense of touch than by sound. The roentgen film depicts accurately the nature of the process in the vast major-

pronounced interlobar pleuritis, the differentiation between rupture and nonrupture into the fissure appears impossible. How-
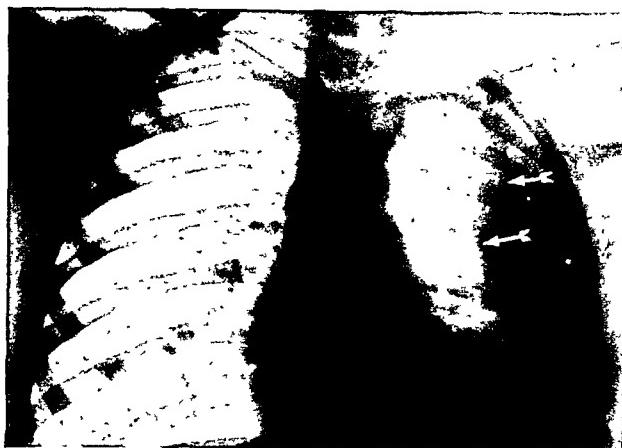
FIG. 1. Loculated lateral empyema. The collection, situated in the axilla, extends over the apex of the lung (confirmed at operation). Note the sharp anterior and posterior margins (arrows). Note also the scoliosis, not uncommon in empyema in children.

ity of cases, and errors in diagnosis are to be ascribed to errors in interpretation and not to shortcomings of the method. Only rarely will obscuring or overlying shadows render impossible a satisfactory study of the pleural encapsulation. In our experience almost all errors in roentgen diagnosis could be recognized as such after the existence of encapsulated empyema was disclosed by operation if re-inspection and restudy of the films were made. The reverse was also true, namely, the absence of encapsulated empyema, erroneously diagnosed on roentgen examination, can also be established by study of the films.

The outstanding exception to the foregoing statements is to be found in the roentgen diagnosis of encapsulated empyemas (or pyopneumothorax) due to perforation of pulmonary abscesses of substantial proportions. In not a few instances we have operated on the roentgen diagnosis of perforated pulmonary abscess to find the abscess of the lung unperforated at the time of operation. It is our impression that the roentgen diagnosis cannot be made at times. Thus, when a pulmonary abscess faces an interlobar fissure with resultant

ever, the diagnosis of perforation of an abscess can be made in most instances on the basis of two features: (1) The existence of a considerable area of homogeneous density with sharply defined convex margin, and (2) the existence of two (or more) adjacent areas of rarefaction as well as of two (or more) fluid levels. Should an earlier film have revealed an uncomplicated pulmonary abscess, later films would, of course, establish the diagnosis if the pleural complication were depicted. (Fig. 1.)

Turning now to the special roentgen diagnosis of encapsulated empyemas, it can be said that purulent collections may occur anywhere in the pleural cavities. They are found most often in the general pleural space, that is, outside interlobar fissures. Because their locations present peculiar problems in diagnosis and surgical approach, five groups will be discussed separately. As a statement applying to all groups it should be said that the diagnosis of the existence as well as the extent of encapsulated empyemas in any of these groups may depend on oblique, lateral or other views in addition to the conventional postero-anterior films. This is particularly

true of small encapsulations in atypical places such as the retrocardiac, supra-diaphragmatic or mesial regions.

sympathetic effusion. In the case of very large encapsulations the roentgen diagnosis may be difficult or even impossible if
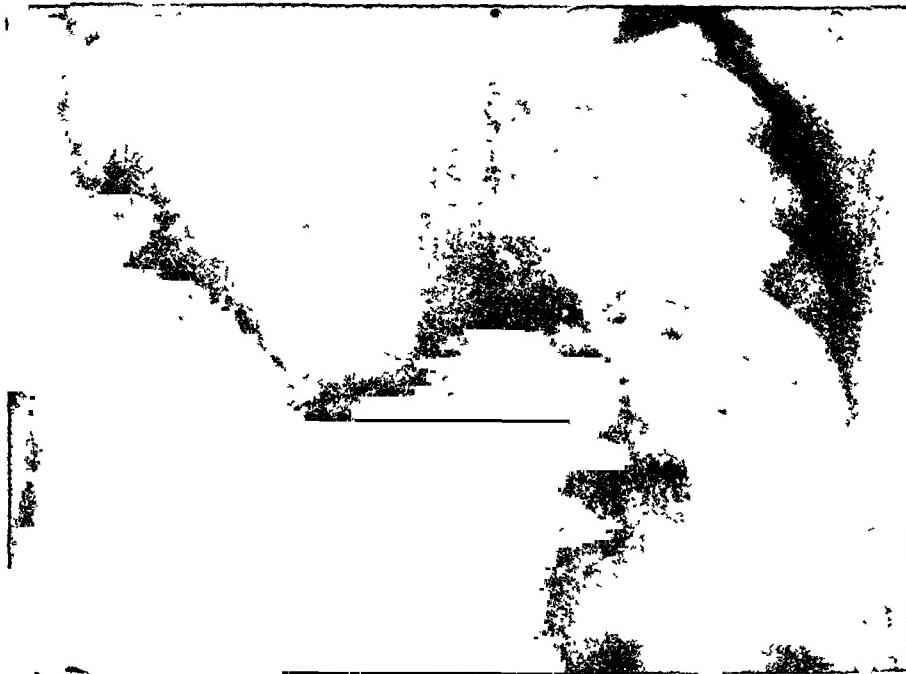
Fig. 2. Bilocular empyema. One collection is subapical and the other, lateral. Note the characteristic sharp delimiting margins.

A. *Encapsulations over the convexity*, which are the most common, are located on the anterior, posterior or lateral aspects of the convex curve of the chest wall.

B. *Mediastinal*. These occur on the mesial or mediastinal aspect of the general pleura.

C. *Supra-* or *periapical* surmount or surround the apex of the lung.

D. *Infrapulmonary*. These occur between the undersurface of the lung and the uppersurface of the dome of the diaphragm.

E. *Interlobar* are loculated between opposing surfaces of the interlobar pleura. (Fig. 2.)

A. *Collections over the Convexity*. These empyemas vary in size from large collections to small pockets containing but a few cc. of pus. The smaller collections usually present no great difficulty in diagnosis. Occurring in conjunction with the shadow of a pneumonic lesion and revealing well defined margins, the diagnosis is usually evident. They may, however, be obscured by a large pneumonic lesion with surrounding abundant plastic exudate or by a

pleural delimitation of a homogeneous shadow is not visible.

Multiple views are imperative in order to disclose loculation if a homogeneous shadow is present with consolidation of the lung.

Bizarre appearances are often seen in cases of multiloculated empyema. If surgical drainage has already been instituted, repeated radiographic examinations may be necessary to determine if loculations intercommunicate or to disclose other collections previously unrecognized. When pyopneumothorax occurs following the rupture of a lung abscess, even fluoroscopy and films made in many projections, with the patient in both the erect and lateral recumbent positions, may not suffice to distinguish between an intrapulmonary or an intrapleural lesion. Suggestions for differential diagnosis have already been made. (Fig. 3.)

B. *Paramediastinal Empyema*. These collections are situated on the mediastinal aspect of the pleura, immediately adjacent to the anterior, middle or posterior medias-

tinum. Because of the superimposition of shadows on the heart, great vessels and other mediastinal structures, unusual pic-

FIG. 3. Large lower paramediastinal empyema. The technic used demonstrates the separate overlapping shadows The appearance might otherwise simulate an enlarged heart.

tures are produced which are often difficult of correct interpretation. However, the diagnosis by roentgenology can be made in the majority of instances if the essential features of localized empyema, to which attention has been called, are borne in mind.

Some of the problems in diagnosis may be cited. When the empyema occurs in the lower mediastinum, the appearance may simulate cardiac enlargement or localized pericardial effusion. This is especially true if the exposure technic results in films with marked contrast, so that the overlapping cardiac and pleural shadows cannot be separated.

When the empyema occurs in the upper mediastinum it may simulate, on the postero-anterior projection, an aortic aneurysm or mediastinal tumor. If the loculation extends laterally enough, its anterior and posterior margins may be sharply defined on the lateral projections. In the case of a shallow empyema the longest diameter often is in the sagittal plane; its anterior and posterior adhesions will not be clearly visualized in contrast with mediastinal shadows.

The differentiation between a large paramediastinal empyema and a mediastinal abscess may be impossible roentgenologically. A lead may be found in a sympathetic pleural effusion or in a second pleural loculation. Occasionally, a pulmonary abscess facing the mediastinum may rupture into that potential space producing an encapsulation which is impossible of roentgen differentiation from paramediastinal empyema. (Fig. 4.)

C. Supra- or Peri-apical Empyema. This variety of empyema is rare. In the cases we have seen it has been the result of a rupture of a pulmonary suppurative focus or a loculation separated by adhesions from a generalized empyema which had extended over the apex. In two instances a supra-apical empyema acted as a cowl over the top of the lung, requiring both anterior and posterior upper thoracic drainage. The x-ray film shows a homogeneous shadow extending downward for a variable distance from the dome of the hemithorax. The inferior margin of the shadow is usually sharp in outline. No air-bearing tissue is seen above this shadow. While the appearance may be considered to be characteristic, we have seen identical roentgen evi-

dence in cases of apical pneumonia with plastic exudate, atelectatic upper lobe in a child, and in pulmonary abscess.

Malignant neoplasms occupying the apical and paravertebral portions of the

the lung merging with the density of the liver (on the right side). The x-ray appearance may be indistinguishable from that of subdiaphragmatic abscess.

FIG. 4. Supra-apical pyopneumothorax, occurring with a lateral collection. Note the absence of lung markings at the apex.

apical and paravertebral portions of the upper lobe may present features closely resembling those of apical or peri-apical empyema. Destruction of overlying ribs, usually visible in roentgen films, often establishes the diagnosis. The differentiation from empyema may be particularly difficult if secondary pleural infection or carcinomatous pleural invasion supervenes.

D. *Infrapulmonary Empyema.* This term is applied to an encapsulated collection of pus situated between the under surface of the lung and upper surface of the dome of the diaphragm.[5] Infrapulmonary empyemas vary in extent from lesions which are small and are entirely separated from the chest wall by adherent lung, to the larger collections which encroach on the pleura of the thoracic convexity.

When the lesion is small, it is apt to be overshadowed by adjacent pulmonary infiltration. Larger localized infrapulmonary encapsulations usually elevate and arch the diaphragmatic surface of the lung. As a result, a shadow is present at the base of

As already noted, an infrapulmonary empyema of large size usually extends into the general convex portion of the pleural space, generally in its posterior aspect. If the parietal extension is small, it may be overshadowed by the original collection; while if large, it may obscure the infrapulmonary lesion. Lateral films may aid greatly in resolving the shadows. (Fig. 5.)

When an infrapulmonary pyopneumothorax is present, the infiltrated compressed lower lobe is usually elevated by a collection of air surmounting the fluid level. This appearance is difficult to differentiate from a gas-containing subphrenic abscess. The induction of a small pneumoperitoneum may delineate the dome of the diaphragm and thus disclose the situation of the lesion. The same procedure may aid in the differentiation of infrapulmonary lesions which do not contain air.

A useful sign of an infrapulmonary empyema, not present in all cases, is the displacement of the heart away from the side of the lesion. This sign is particularly

valuable when the empyema is small and may be mistaken for pneumonia.

E. Interlobar Perforated Pulmonary Ab-

In another case, in films taken at intervals, there was seen the progression of disease along an interlobar fissure. This was found
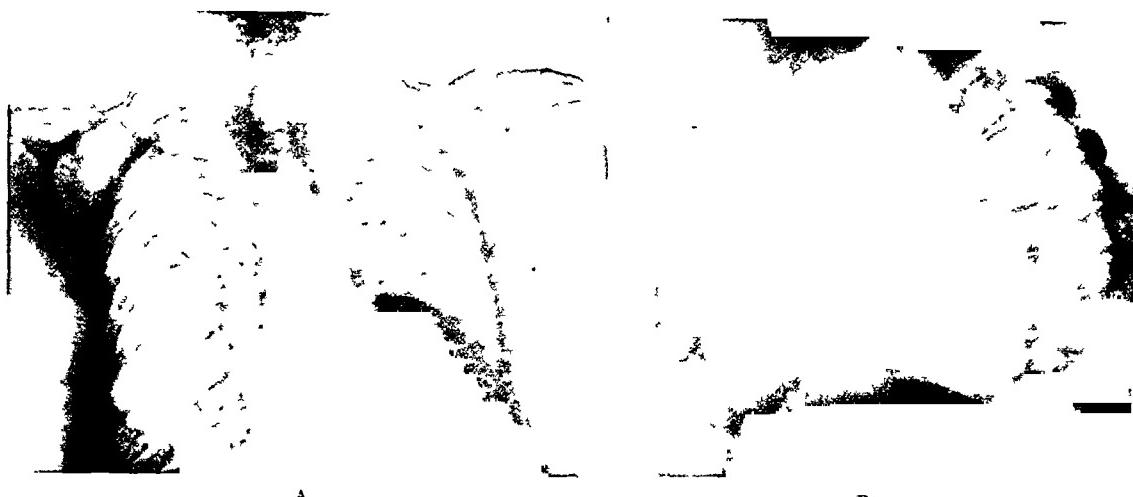
FIG. 5. A, anteroposterior view of infrapulmonary empyema. The appearance simulates an elevated left dome of the diaphragm, possibly as a result of subphrenic abscess. B, lateral view. The lateral projection illustrates the large posterior parietal presentation.

scess ("*Interlobar Empyema*"). As we have shown elsewhere[1,2] all cases of true interlobar collections of pus have proved, in our experience, to be cases of perforated pulmonary abscess. The latter term can, therefore, be applied properly to the group of cases in which pus is encapsulated in interlobar fissures. About half of the cases in our series presented roentgenological evidence to indicate the presence of interlobar disease. Since it is important to recognize the existence of an interlobar abscess for purposes of accurate surgical approach and management, a statement of the positive roentgen features is warranted.

An oval or elliptical shadow limited by the interlobar fissures, or overlying the region of the fissures, or the presence of a pyopneumothorax limited by the interlobar pleurae is strongly suggestive evidence. However, only the latter film can be regarded as pathognomonic for we have seen apparent intrafissural lesions prove at operation to be due to pulmonary infiltration.

A fluid level abutting on, or traversing, a fissure should also suggest the possibility of an interlobar collection. Bowing of a fissure, due to pressure by a large interlobar collection of pus was noted in one of our cases.

to be due to an interlobar abscess which had gradually enlarged by dissecting along the interlobar pleural space.

In about half the cases we reported there was no distinctive roentgenological evidence to suggest the diagnosis. In some the lesion was obscured by large pleural effusions; in others, the pulmonary lesion dominated the picture. There was one instance in which a sharply circumscribed shadow seen in the roentgenogram was thought to be due to a pulmonary neoplasm.

THORACOCENTESIS FOR DIAGNOSIS

The foregoing discussion on various aspects of the subject of encapsulated empyema indicates clearly that the diagnosis is difficult in not a small proportion of cases. As compared with diffuse empyema in which thoracocentesis often is performed only for confirmation of the diagnosis, exploratory puncture is not infrequently required in an effort to establish the diagnosis of encapsulated empyema. Indeed, there are instances in which very carefully performed exploratory aspirations fail to reveal pus, cases in which exploratory thoracotomy is indicated rather than to subject the patient to indiscriminate (and possibly dangerous) multiple aspira-

tions. Since the diagnostic thoracocentesis evidently occupies a vital place in the management of encapsulated empyema, it should be performed under the most favorable auspices. The latter implies first, readiness to proceed with operation if pus is encountered, the needle being left in place if the empyema is small or difficult to find by aspiration, and secondly, careful roentgenological study. Encapsulated empyema rarely is a lesion urgent for operation and ample time, therefore, is available for complete roentgen films taken in the various positions required by the individual case. Only then will the correct intercostal space for exploratory puncture be disclosed, namely, the site at which there is contact between the empyema and the thoracic parietes. Since absence of such contact is decidedly unusual, as has already been stated and since adequate roentgen studies will reveal the precise site of contact, pus should not only be encountered promptly in most instances but also superficially. Deep aspiration is warranted only in the unusual instances already referred to (interlobar, infrapulmonary, paramediastinal, high axillary empyemas) in which the main collection of pus is not in contact with the thoracic convexity. It is also evident that deep aspiration may reach an underlying pulmonary abscess and not the empyema. Finally, reference should be made to the fact that the diagnosis of empyema is not necessarily established when only small amounts of pus are obtained by aspiration. Errors in diagnosis have been made since such small quantities may be obtained directly from the infected lung. The danger of infection of a previously uninfected pleural space under such circumstances is obvious. That errors have been made has been proved at operation, in cases in which the pleural space has been found to be free from any suppurative lesion.

SURGICAL TREATMENT

The prerequisite for correct operative treatment of sacculated empyema is precise roentgen localization of the lesion with special reference to its contact with the thoracic parietes. The essential step in the operative procedure is adequate exposure of the parietal pleura in order to visualize the presence (or absence) of pleuritis at the site of proposed entry into the collection of pus. Obviously, we regard entry of the free pleura as the outstanding danger of operation for encapsulated empyema. It can be said that this danger scarcely exists when encapsulations are of large size. Yet we know of instances in which the general pleural space has become infected as the result of being entered in such cases. In any event, in the case of moderate sized, or more particularly of relatively small encapsulations, the danger is real unless preoperative localization is accurate and the parietal pleura is visualized at operation. As has been pointed out, the free pleura must of necessity be traversed in specified, relatively rare instances in order to gain access to collections of pus. With the knowledge that slight, if any, contact is present in such cases the free pleural cavity can be entered, packed off and traversed in a one- or two-stage operation without becoming infected.

In our opinion, closed drainage has little or no place in the operative treatment of encapsulated empyema, even in children. There are three reasons for our view: First, the well known indications for closed drainage rarely exist in cases of localized empyema. It can be added that closed drainage rarely would be curative for encapsulated empyema, and would therefore be only a preliminary procedure. Secondly, closed drainage is too blind a procedure for localized empyema, the danger of infection of the free pleural cavity existing unless the empyema is of large size. Thirdly, closed drainage not only is unnecessary but is almost certain to be ineffective for adequate drainage, particularly in the presence of loculations of pus or of an underlying perforated pulmonary abscess of substantial size.

Local anesthesia is the anesthesia of choice for operations for encapsulated empyema; only rarely should supplement-

ary general anesthesia be necessary. There are two special advantages in local anesthesia: first, the danger of spillover infection to other pulmonary segments is minimal in the event of underlying pulmonary abscess communicating with the bronchial tree; secondly, the patient can cough or strain on request during operation and as a result reveal a pocket or pockets of pus which otherwise might be overlooked. If inhalation anesthesia must be used, positive pressure can be employed to disclose such pockets.

The liberal excision of a portion of one rib usually suffices for adequate exposure of the pleural abscess provided the correct rib has been chosen. After the collection of pus has been entered the parietal pleura should be split open to unroof the empyema completely, if possible. In so doing every precaution should be exercised to avoid entry of the free pleural space, and reliance should be placed on visualization rather than on sound because the hiss or blow of an open pleura resembles closely that of an open bronchus.

After the main collection of pus has been laid open satisfactorily and evacuated by suction an examination is made for communicating locules. The roentgen film may have already demonstrated their existence and situation and the direction in which they are to be sought has, therefore, been indicated. However, additional pockets may be found in cases in which there is no preoperative evidence to indicate their existence. It is important to note that communications between locules and the main cavity may be via narrow and tortuous channels sometimes situated in relatively inaccessible recesses of the parent abscess. The use of a sterile light for the examination for recesses and communications is invaluable. Coughing or straining by the patient may reveal a pocket which otherwise might be overlooked. Ramifications from the primary cavity can usually be laid open from within but may require enlargement of the wound with additional rib removal. At times counterincisions are necessary, particularly when secondary

pockets are in contact with the thoracic parietes at sites remote from the original incision. A single cavity should be the objective of operation and can be achieved in the preponderance of cases. Under such circumstances the cavity and any recesses which exist can be packed with gauze at the end of operation. Tube drainage in addition to gauze packing of the main cavity should be reserved for those exceptional instances in which wide opening of the main or secondary collections of pus has not been carried out.

The relationship between pulmonary abscess and encapsulated empyema was taken up in the first section. The operative treatment of the pulmonary abscess should now be discussed. It should be stated at the outset that a unanimity of views does not exist at the present time. There is the widely held view, to which reference has been made, that pleural perforation of a pulmonary abscess may be or is tantamount to cure of the abscess, and the obvious corollary that operative treatment of the abscess is not indicated. We believe that the latter applies to many cases but that rigid adherence to such a plan is dangerous. Thus, there are not a few cases in which the pulmonary abscess is of substantial size and the perforation insignificant. In such cases the pulmonary symptoms may be prominent or may even dominate the clinical picture. In our opinion, such pulmonary lesions should be cared for at the time of operation for empyema. The justification for this view is to be found not only in the desirability of eliminating the symptoms of pulmonary abscess but also in the extreme simplicity of the operative procedure. The latter consists in visualizing the opening in the pulmonary abscess, splitting it crucially if found to be too small and inadequate for drainage of the pulmonary cavity, the insertion of narrow-bladed retractors and inspection of the interior of the cavity for recesses, and the gauze packing of the pulmonary cavity and its recesses after it has thus been adequately unroofed. Only rarely will a patient's condition be too poor

to withstand this simple and brief additional operative procedure.

Special reference should be made to the subject of putrid empyema in connection with the question of management of the underlying abscess. It has been shown elsewhere[3] that an abscess is to be demonstrated as the almost invariable cause of an encapsulated collection of foul pus in the pleura. When profuse expectoration of foul pus is a symptom, a pulmonary abscess of substantial proportion can be anticipated. The pulmonary lesion may be seen in films which antedated, as well as in those taken at the time of pleural invasion. In our opinion, adequate unroofing of the perforated pulmonary abscess is imperative under such circumstances. Putrid pulmonary abscess is a far more dangerous lesion than aerobic or nonputrid pulmonary abscess and temporization, which may be warranted in the one is unjustified in the other. In either instance the possibility of spontaneous recovery exists. In the case of a putrid lesion, however, the possibility should not be banked on. The argument in favor of deferring the unroofing of a perforated abscess to a later date in order to ascertain if the procedure proves to be indicated can be refuted on three counts: (1) During the interval there may be a spread of the anaerobic (putrid) infection beyond the limits of the pulmonary abscess not only locally, but also in remote segments. (2) Spread of infection may occur insidiously with few, if any, symptoms of pulmonary abscess and without characteristic roentgen features. (3) Unroofing at the time of the primary operation is simple and safe, whereas the abscess may be difficult to find and not simple and safe to drain at a deferred operation.

The immediate results of primary unroofing of perforated abscesses at the time of operation for putrid empyema are striking in the prompt recession of the symptoms of pulmonary abscess. Furthermore, symptoms do not return if the pulmonary cavity is not permitted to close prematurely. Special post-operative attention to the pulmonary cavity is required after an

abscess has been unroofed. The cavity should be kept open by packing and the bronchial fistula must be maintained until all evidence of anaerobic infection has disappeared. Infection within the pulmonary cavity may persist after the empyema space has become quite clean. Therefore, the opening in the lung may prove to be the last part of the wound that is kept open. The foregoing remarks were made specifically in reference to perforated putrid abscess but apply also in a general way to the postoperative management of perforated aerobic abscess.

Although the operative treatment of the pulmonary lesion comprises the most distinctive feature of the surgery of encapsulated empyema, the basic principle of treatment is complete drainage of the suppurative focus without infection of the free pleural space. There is a rather general belief that the results of operation for empyema are related to the underlying cause rather than to the operative technic. This belief is justified in some cases but cannot be enunciated as a dictum. Not only morbidity but also mortality can be directly ascribable to a badly conceived or incorrectly executed operation for encapsulated empyema. On the other hand, uniformly good results can be anticipated, unless the underlying cause is irremediable surgically (pulmonary cancer, actinomycosis, etc.), if operations are based on accurate preoperative studies and are carefully executed in accordance with a well conceived plan.

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BRONCHIECTASIS*

MORBIDITY AND MORTALITY OF MEDICALLY TREATED PATIENTS

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THE pathology of bronchiectasis was described in considerable detail by Laennec more than a century ago. However, a fairly precise knowledge of the etiology, pathogenesis, bacteriology, and the morbidity and mortality of the disease, has been accumulating only during the past seventeen or eighteen years, or since Sicard and Forestier first used iodized oil in bronchography. Despite the rapid advances in our knowledge and concepts of bronchiectasis during these recent years, considerable differences of opinion still exist regarding many aspects of the disease. Mueller, in 1928, and Ballon, Singer and Graham, in 1931, and more recently, Miller and others, emphasized the congenital nature of bronchiectasis; however, Perry and King, Warner, McNeil, Findlay and Sauerbruch, to mention but a few, have expressed considerable doubt regarding the congenital nature of the condition. In a large series of cases observed at Bellevue and Lenox Hill Hospitals during the past ten years, no proved case of congenital bronchiectasis has been seen by the writer. Occasional writers still emphasize the rôle of spirochetes, although the majority of workers in this field minimize their importance in bronchiectasis.

Of greater practical importance is the differences of opinion regarding the treatment of bronchiectasis. In many clinics where large series of cases are being collected, followed and studied, a more unified and clear conception of the natural course of the disease and its treatment is emerging. Nevertheless wide differences of opinion

still exist as evidenced by reports in the literature by members of the various specialties, extolling different methods of treatment. These differences in point of view between certain internists, roentgenologists, bronchoscopists and surgeons, apparently spring from differences of understanding of the fundamentals of the disease—its etiology and pathology, pathogenesis and pathological physiology, bacteriology, the varied clinical patterns, its usual course characterized by natural remission of symptoms for long periods of time, frequently to be followed by exacerbation and progression of the disease, often eventually resulting in hopeless chronic invalidism if the proper treatment is not rendered at the opportune time. Bronchiectasis is often similar to pulmonary tuberculosis in that it tends to relapse and progress; and also most cases of bronchiectasis, like most cases of tuberculosis, are potentially curable at some phase of the disease. Often, circumstance, patient and doctor contrive to overlook this opportune moment and fail to choose the best method of treatment.

The internist who hopefully administers arsenicals because of the erroneous conception that spirochetes constitute the principal bacteriological agent in the usual case of bronchiectasis, apparently lacks a comprehensive understanding of the great variety of micro-organisms which play a part in the etiology of the disease. The internist or roentgenologist who enthusiastically administers x-ray therapy apparently does not fully appreciate the

pathological physiology, not only of the ectatic bronchi but also of the related diseased lung parenchyma. The bronchoscopist who believes that weekly aspiration of the stem bronchi, with or without lavage with some "bactericidal" agent, is sound and adequate therapy, also fails to visualize the pathology, pathological physiology and bacteriology of the disease, as well as the limitations of bronchoscopic aspiration and "bactericidal" solutions. The following case serves to illustrate:

G. L., male, aged thirty-four (Figs. 12 to 15) was first seen in our clinic in 1934. He gave a history of having had bronchiectasis for seventeen years, and stated that during the preceding fourteen years, he had been bronchoscoped "more than 200 times." His willingness or apparent desire to continue with a method of treatment which apparently had had no beneficial influence on his symptoms, was probably because of the "reaction" which resulted from the large amount of cocaine used for the local anesthesia before bronchoscopy. The patient died of bronchopneumonia in 1938, having had saccular bronchiectasis for at least twenty-one years, and having been bronchoscoped something over 200 times, and having refused lobectomy because he "believed" bronchoscopy would eventually cure his disease.

It would seem that the time has come when sufficient knowledge is available regarding the fundamentals and the natural course of the disease so that a more unified opinion among the various specialties and specialists might crystalize as regards the treatment of bronchiectasis.

Although the present paper is especially concerned with the morbidity and mortality of medically treated bronchiectasis, some discussion of the present concepts of etiology, pathogenesis, and bacteriology, and certain principles of treatment based on these fundamentals, seems desirable. Sound management and treatment of bronchiectasis is dependent upon a comprehensive understanding of these fundamental principles, the various clinical patterns or types of the disease, its natural course, its obvious and potential hazards,

the limitations of medical therapy and the curability of single and multiple lobectomy or pneumonectomy, and the morbidity and mortality of untreated and medically and surgically treated bronchiectasis.

ETIOLOGY AND PATHOGENESIS

Numerous theories and opinions have been advanced regarding the etiologic and pathogenetic factors of bronchiectasis. Not a few writers have emphasized the congenital nature of the condition and have theorized that the condition is not discovered more often earlier in infancy and childhood, because until infection results, the patient may not have symptoms to focus the attention of the physician on the congenital defect of the bronchi and lung.

Andrus and others have emphasized the importance of physical forces resulting from collapse of the lung in the production of bronchiectasis. Pediatricians, including Anspach, McNeil, and Richards have pointed out that collapse of a lobe may occur in children with pneumonia, and bronchiectasis is sometimes a sequel. Perry and King discuss the importance of "collapse" of a lobe following pneumonia as an important etiologic factor in their large series of cases, and state that, "in 167 patients (42 per cent of their series), the age of onset was in the first decade, a period when pneumonia, measles, whooping cough and other contagious fevers are common and these diseases may give rise to collapse."

Clerf, Jackson and others have discussed the importance of inhalation of foreign bodies with subsequent chronic pulmonary and bronchial infection, as an important etiologic factor in bronchiectasis.

Until a few years ago, most authors and teachers in this field held that bronchiectasis was secondary to chronic disease of the paranasal sinuses. Despite the fact that for many years this idea was almost universally accepted, considerable evidence has come to light recently to indicate that the disease is not necessarily always associated with or secondary to chronic sinus disease.

Goodale, Perry and King, have suggested that while bronchiectasis and chronic sinus disease are often associated, bronchiectasis

considering the etiologic relationship of the two conditions, it should be remembered that bronchiectasis usually has its onset

FIG. 1.   FIG. 2.

FIGS. 1 AND 2. W. B., white male, aged thirty-one, was first seen in 1937 complaining of cough, expectoration and hemoptyses. His parents had told him that he had "pneumonia" after "swallowing" a "buckshot" at the age of one. He had had cough and expectoration of mucoid to mucopurulent sputum as long as he could remember, was subject to chest colds and had had several attacks of "pneumonia" always on the right side. He had small recurrent hemoptyses during the past four or five years. When first seen, he was in good general health. There was marked clubbing of the digits and numerous sibilant râles and rhonchi were heard below the third anterior rib and seventh spine on the right. X-ray (Fig. 1) shows a foreign body, apparently a buckshot, at the level of the fourth anterior interspace right, and saccular bronchiectasis with a moderate amount of fibrosis. Bronchogram (Fig. 2) confirmed the diagnosis of extensive saccular bronchiectasis of the right middle and right lower lobes. Dr. Girard Oberrender was unable to see or remove the foreign body bronchoscopically. The patient refused lobectomy, is still in good general health and working full time.

is not always secondary to the former condition, nor is sinus disease always present in cases of bronchiectasis.

In one hundred cases studied at the Lenox Hill Hospital during the past ten years, thirty or 30 per cent had definite chronic sinus disease. A careful analysis of the case histories of these thirty patients revealed that twenty or 66.6 per cent had symptoms, findings, or both of bronchiectasis, from several months to several years *before* they developed evidence of chronic sinus disease. From these observations and others made at Bellevue Hospital, some with Dr. Edith Lincoln on the Pediatric Service, and others on the Tuberculosis Service, a definite impression has resulted, that chronic sinus disease is perhaps more often *secondary* to bronchiectasis than it is a cause of, or important etiologic factor in, the development of bronchiectasis. In

during childhood or early adult life while chronic sinus disease has its onset relatively *later* in life. In their large series of cases, Perry and King reported that the onset of bronchiectasis occurred during the first decade in 42 per cent, and during the second decade in 27 per cent of their patients. They did not give figures to indicate the seniority relationship of the two diseases. In the series of cases studied at the Lenox Hill Hospital Clinic, the onset of the bronchiectasis apparently occurred in the first decade in 41 per cent and during the second decade in 23 per cent of the cases. These figures tend to confirm our belief that paranasal sinus disease is not infrequently secondary to bronchiectasis.

In the classical case of bronchiectasis which frequently develops following bronchopneumonia in children, often when streptococci are implicated, the early

pathological changes which eventually lead to demonstrable ectasia of the bronchi are not confined to the bronchial wall, but also

resolution and healing and many of the areas progress to a state of irreversible fibrosis; and if the chronic infection con-

FIG. 3.   FIG. 4.

FIGS. 3 AND 4. B. P., white male child, aged two when first admitted to the hospital in 1932 with bilateral bronchopneumonia which developed following measles. (Fig. 3.) On admission, the patient was acutely ill, cyanotic, dyspneic and required oxygen for several days. Dullness, diminished breath sounds and later, bronchovesicular and bronchial breathing and numerous râles were present over the middle and both lower lobes. Sputum typing was negative for pneumococci, but cultures showed hemolytic streptococci predominating. The patient made a slow convalescence. During the following winter, the patient had two attacks of bronchopneumonia with slow convalescences. Numerous moderately coarse râles persisted over the middle and both lower lobes. Lipiodol bronchogram shows the presence of early predominantly saccular bronchiectasis especially in the right lung. (Fig. 4.)

often, if not almost always, simultaneously involve the lung parenchyma. (Figs. 3 and 4.) Consequently, as a result of repeated attacks of bronchopneumonia, which may occur during a single winter and subsequent spring season, these rather insidious and chronic inflammatory changes in the bronchial mucosa and submucosa and lung parenchyma develop and progress. Serial chest roentgenograms at this time may show failure of the lungs to clear completely following one of these attacks of more or less atypical bronchopneumonia. During the summer season, the patient may improve clinically and roentgenological study may show almost complete clearing of the patchy and linear areas of residual inflammatory changes. However, during the following winter season, upper respiratory infections are apt to be followed by evidence of low-grade bronchopneumonia with associated chronic inflammatory changes of the bronchi. Often these chronic inflammatory changes fail to undergo complete

tinues or is repeated, as is likely, further fibrosis of the involved lobe with shrinkage and contraction of the lobe or segment, eventually results. Simultaneous with the development of these chronic parenchymal changes, similar progressive chronic inflammatory changes result in the bronchial wall. After prolonged or protracted periods of infection and repeated exacerbations, certain irreversible changes occur in the tissues comprising the bronchial wall. Areas of chronically infected granulation tissue replace the normal epithelial lining of the bronchus, the elastic fibers and the muscle bundles are partly or largely replaced with fibrosis, and in some instances, destruction of the cartilaginous structures of certain bronchi may result. As a consequence of these destructive onslaughts, weakening of the bronchial wall results. At this time, various physical phenomena, including shrinkage and contraction of a segment or of an entire lobe as a result of extensive fibrosis and, comparatively ineffective and

excessive coughing, combine with other factors to cause dilatation, or ectasia of the bronchi. Also, as a result of chronic inflam-

vulnerability of the diseased lung and bronchi to further endogenous or exogenous infection. These changes make it obvious

Fig. 5.

Fig. 6.
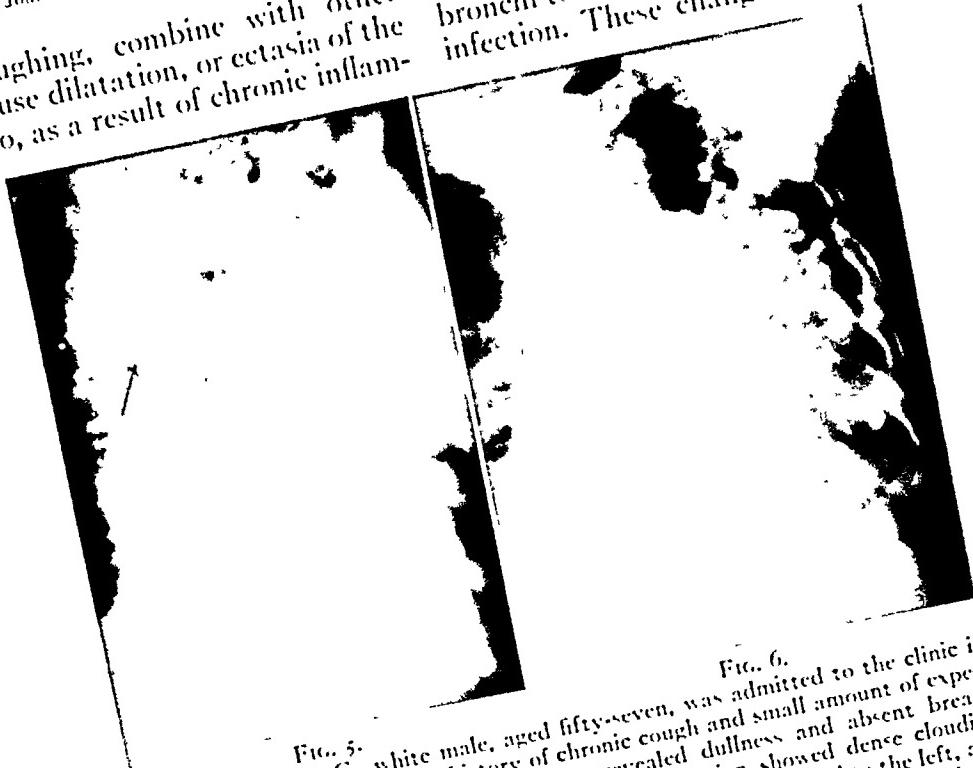
Figs. 5 and 6. G. C., white male, aged fifty-seven, was admitted to the clinic in good general health with a history of chronic cough and small amount of expectoration for many years. Examination revealed dullness and absent breath sounds throughout the left chest. X-ray examination showed dense clouding throughout the left side with the mediastinal structures deviated to the left, and numerous annular areas of decreased density. Lipiodol bronchogram shows occlusion of the left stem bronchus. (Fig. 5.) Bronchoscopy revealed a hard, round tumor occluding the left stem bronchus, which was removed by Dr. John D. Kernan. Histologic studies showed the tumor to be osteochondroma. Following the removal of the tumor, the patient expectorated large quantities of purulent sputum having a foul odor. Bronchogram was repeated and revealed extensive saccular bronchiectasis involving most of the left lung. (Fig. 6.)

mation, stenosis may develop in the stem, secondary or tertiary bronchi, frequently beyond the visualization of the bronchoscopist. As a partial consequence of the stenosis, the diseased and weakened bronchi become further dilated distal to the stenosis. Pooling of purulent and often anaërobically infected secretions occurs in the ectatic areas. These factors combine to bring about the saccular bronchiectasis often spoken of as congenital or cystic bronchiectasis.

As a result of these extensive pathological changes in the lung parenchyma and bronchi, the normal cleansing power and the physiological function of the bronchi and lung become greatly impaired. Thus a vicious cycle develops which increases the

why many patients with bronchiectasis are likely to suffer protracted and repeated relapses and exacerbations, and also indicate why the disease is usually progressive, if not in the actual development of new bronchiectatic areas in previously healthy parts of the lung, certainly often in the development of an increasing amount of secondary or associated pulmonary fibrosis, emphysema, and or suppurative pneumonitis.

Various other conditions may play a part in the development of bronchiectasis. Any condition which predisposes to, or causes the development of chronic inflammatory changes in the lung parenchyma and bronchi, may lead to the development of bronchiectasis. This is especially true in
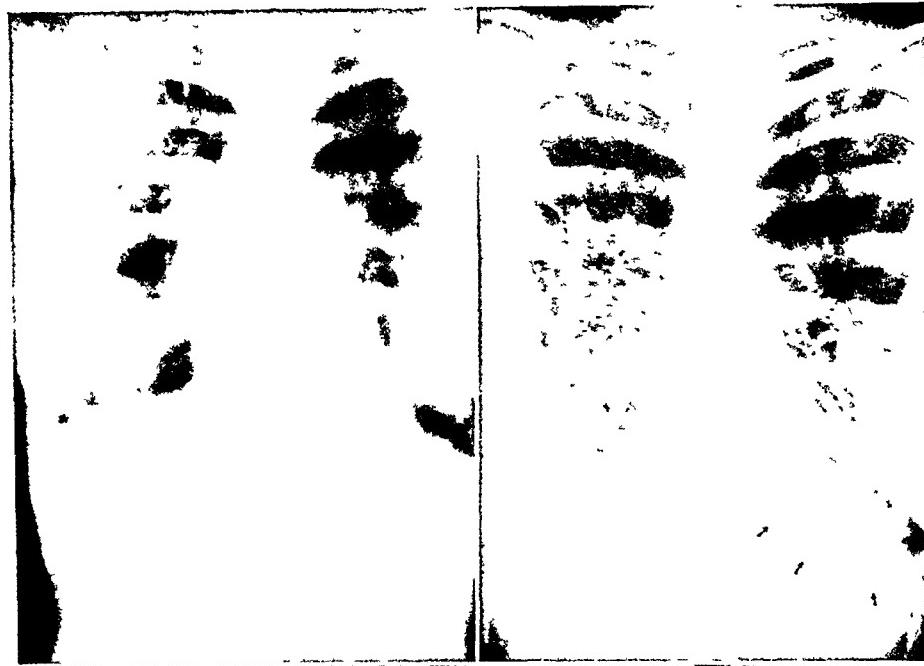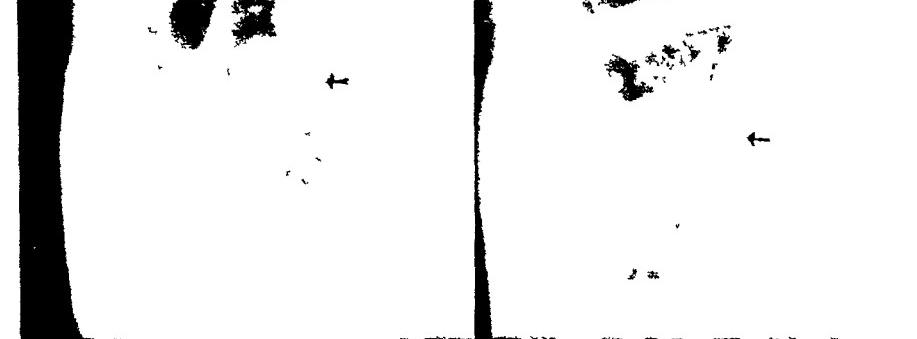
Figs. 7 to 10. H. G., white female, was admitted to the clinic in 1930 at the age of seventeen, with a history of chronic cough and expectoration, dyspnea, and repeated attacks of "bronchitis" and bronchopneumonia since early childhood. Examination showed an emaciated, tall girl, appearing chronically ill. There was no clinical evidence of chronic sinus disease and x-ray examinations of the paranasal sinuses were negative. The percussion note over both lungs was hyperresonant especially on the left, posteriorly. Breath sounds were diminished over both lung fields and numerous sibilant râles and rhonchi were heard over the lower half of both lungs. Chest x-ray (Fig. 7) reveals linear and patchy areas of fibrosis in the right lower two-thirds, and to a much less extent in the lower half of the left lung. Lipiodol bronchogram four years later (Fig. 8) shows cylindrical bronchiectasis involving the right middle and both lower lobes. At this time, the evidence of emphysema was much more marked than in 1930. The left diaphragm is markedly depressed. (Fig. 8.) Cough, expectoration and increasing dyspnea continued and the patient developed abscess in the right lower lobe. (Fig. 9.) The lung abscess was thought to result from a "spill-over" of infectious secretions from the bronchiectasis. Because of the poor general condition and marked dyspnea, surgical drainage was not done. During the next few months, the lung abscess gradually contracted (Fig. 10), and finally disappeared. Five years later, the patient is in fairly good health but remains quite dyspneic. This case illustrates two complications of bronchiectasis: (1) the development of marked emphysema, especially of the left lung (Fig. 8), and (2) lung abscess of the right lower lobe. (Fig. 9.)

children whose bronchi are more vulnerable to potential destructive forces than are bronchi in adults. Bronchial polyps, benign tumors, stenosis of the bronchi resulting from tuberculosis of the bronchial wall, or other causes, may interfere with the normal cleansing power of the bronchi and promote aspiration and retention of infectious secretions with the subsequent development of lung abscess, suppurative pneumonitis or indurative pneumonia and bronchiectasis. Partial or complete occlusion of relatively easily compressible bronchi of children, by enlarged caseous tuberculous tracheobronchial and mediastinal nodes, may not infrequently lead to atelectasis, chronic suppurative pneumonitis, indurative pneumonia and bronchiectasis. This mechanism is probably more often implicated in the development of bronchiectasis especially in children, than is generally recognized.

ASSOCIATED AND RELATED CHANGES IN THE LUNG PARENCHYMA

The gross pathological changes in the lung parenchyma in advanced cases of bronchiectasis may be proliferative or fibrotic, emphysematous and, destructive (cavities).

Patients with bronchiectasis rarely develop secondary lung abscess cavities. However, when well defined lung abscesses develop, they are usually located in previously "healthy" and nonbronchiectatic areas of the lung. The development of lung abscess in previously healthy areas of the lung undoubtedly come about as a result of a "spill over," or inhalation of infectious secretions originating in the bronchiectatic areas. While well developed saccular bronchiectasis has not been seen to disappear, we have observed the slow contraction and final disappearance of lung abscess cavities in cases with bronchiectasis. (Figs. 7 to 10.)

Proliferative or fibrotic changes in the lung parenchyma are present to a varying degree in most, if not all cases of bronchiectasis. The degree of such changes may be minimal and largely linear and scarcely demonstrable roentgenologically, occasionally even in cases with extensive bronchiectasis. The degree of pulmonary fibrosis is apparently often related to the amount and character of infectious secretions present. This relationship may also be just the reverse. We have not infrequently observed cases with extensive dry bronchiectasis in which fibrotic changes were conspicuous by their absence, to the extent that even saccular bronchiectasis might be overlooked on the roentgenogram.

In other cases in which there is considerable widely distributed cylindrical bronchiectasis of long standing, associated emphysematous changes may largely obscure roentgenological evidence of pulmonary fibrosis. In still other cases, emphysematous changes may so dominate the clinical and roentgenological picture, that the primary underlying bronchiectasis may not be suspected. Occasionally, the emphysematous changes may be largely limited to the bronchiectatic lobe or lobes. (Fig. 8.) This is particularly true in the earlier phases of the disease, but as lobar emphysema progresses, as is frequently likely, compensatory emphysematous changes now become obvious in the nonbronchiectatic lobes as well.

More or less simultaneous with the extensive development of pulmonary fibrosis and emphysema, secondary related changes of the thoracic cage gradually develop, further limiting the respiratory function and increasing the miserable existence of these sufferers of chronic anoxemia and toxemia. The intercostal spaces become widened, the entire bony cage is more or less fixed in the position of deep inspiration, the diaphragms are flattened and greatly depressed into the abdominal cavity and their bellows action is markedly diminished. As a consequence of these associated and related pulmonary and chest wall changes, the pulmonary reserve is greatly diminished and in many cases, may become so depleted that the least physical effort or slight upper respiratory infection may lead to moderate or

Fig. 11. R. F., a white female, was thirteen years of age when admitted to Bellevue Hospital in 1931. She was sent to the hospital because of an hemoptysis and with a diagnosis of advanced tuberculosis of the left lung. She gave a history of having had pneumonia "many times" during early childhood and had had cough and expectoration as long as she could remember. Examination showed a well nourished girl, apparently in good general health, and moderate clubbing of the fingers. The right lung was negative on physical examination but there was marked dullness and diminished to almost absent breath sounds throughout the left side. X-ray at this time showed dense homogeneous clouding throughout the left lung with small areas of decreased densities suggesting underlying bronchiectasis. The sputum was repeatedly negative for tubercle bacilli. Lipiodol bronchography revealed complete occlusion of the left main bronchus. Bronchoscopy revealed a tumor mass in the left main bronchus. A considerable portion of the tumor was removed and immediately thereafter the patient raised large quantities of purulent sputum having an extremely foul odor. The biopsy from the bronchus revealed benign adenoma, thought by some, however, to be carcinoma. The remainder of the bronchial tumor was removed through the bronchoscope by Dr. John D. Kernan. Serial x-rays showed marked clearing of the left lung. Lipiodol bronchogram (Fig. 11) shows extensive cylindrical and

severe dyspnea or orthopnea, marked fatigue, weakness, mental lethargy, headache, anorexia, loss of weight and, not infrequently, marked psychological disturbances characterized by periods of depression, melancholia and, rarely, dementia. Blood studies may show compensatory pseudopolycythemia and hypochromic anemia. Such cases are hopelessly incapacitated, though frequently not actually ill or febrile for long periods of time.

As a result of the protracted anoxemia and toxemia, serious damage to many vital organs may eventually develop. Amyloid degeneration of the kidneys, liver, spleen and intestines is not infrequent. Myocardial degeneration, cor pulmonale, and eventually right-sided heart failure, and occasional brain abscess, may develop.

Bearing in mind the variety, degree and severity of the pathological changes both in the lung parenchyma and bronchi, and the frequency of anaërobic infection, often resulting in foul odor of the sputum, it is not difficult to visualize the morbidity and mortality of untreated or unsuccessfully treated cases of bronchiectasis.

MORBIDITY

While the mortality of untreated, medically and surgically treated bronchiectasis has been studied and reported by many clinics, the morbidity, a condition most difficult to appraise, has seldom been given the consideration it rightfully deserves.

Chronic invalidism of a physical and psychological nature, often from early childhood through a prolonged miserable life, with the ultimate prospect of death either resulting from pneumonia, lung

saccular bronchiectasis involving both lobes. The patient gradually lost all cough and expectoration, her general condition improved, and during the past ten years, she has completed her high school education and is now working full time as a stenographer, enjoying good health. The bronchiectasis has remained "dry" during the past seven years with rare exceptions following colds.

FIG. 12.

FIG. 13.

FIG. 14.

FIG. 15.

FIGS. 12 TO 15. G. L., a white male, was thirty-four years of age when admitted to the Lenox Hill Hospital Chest Clinic in 1934, with a history of chronic cough and expectoration, frequently with foul odor, since the age of seventeen. The cough and expectoration followed an attack of pneumonia on the left side at the age of seventeen. The patient was well nourished and appeared in good general health. There was marked clubbing of the fingers, and clinical as well as x-ray evidence of chronic sinusitis. Examination of the chest revealed dullness over the lower part of the left lower lobe, numerous coarse rales below the fourth anterior rib and eighth spine. Chest x-ray (Fig. 12) reveals clouding involving most of the left lower third. The patient had been bronchoscoped periodically for the preceding eleven years, however, apparently without any beneficial effect. Bronchogram reveals extensive saccular bronchiectasis of the lower portion of the left lower lobe. (Fig. 13.) Two series of deep x-ray therapy were given in the spring and summer of 1934. A total of 6,000 r units were given. Some of the treatments were mistakenly directed over the upper third of the left lung and following this, the patient developed pain, increased cough, expectoration and fever. X-ray examination at this time (Fig. 14) reveals dense clouding just below the clavicle on the left and perhaps slightly increased clouding at the base. The condition at the left top was diagnosed as x-ray pneumonitis and x-ray therapy was discontinued. The clouding gradually diminished but was still present almost two years later, and appeared to be largely fibrotic in nature at the time. (Fig. 15.) The bronchogram at this time revealed essentially no change in the condition of the bronchiectasis. The patient died of pneumonia several months later. This case illustrates the failure of repeated bronchoscopies and bronchoscopic lavage to influence the natural course of the disease and the disadvantages and dangers of x-ray therapy.

abscess, pulmonary hemorrhage, heart failure or some related complication, is the picture that both surgeon and internist picture of the disease is not always visualized by the surgeon or internist. I have seen experienced general surgeons refuse to do

Fig. 16. H. V., a white male, aged forty-two, was referred by Dr. Jacobsen in 1937 because of repeated hemoptyses, cough, large amounts of occasionally foul smelling sputum, chest pain, occasional bouts of fever and marked fatigue. X-ray examination of the chest in 1922 by another physician, revealed a large area of dense clouding in the mid-third of the right lung field adjacent to the hilum. The only symptoms at the time were severe chest pain and dry cough. Tumor of the mediastinum or right lung was diagnosed at the time (1922). Diagnosis was confirmed by several physicians and the patient was given large doses of deep x-ray therapy during the next few years by different physicians. Chest x-ray in 1937 showed a markedly shrunken and fibrotic right lung, apparently resulting from damage to the lung by large doses of x-ray resulting in chronic interstitial and indurative pneumonitis. Lipiodol bronchogram revealed extensive cylindrical bronchiectasis on the right. About one year later, January, 1938, the patient died of bronchopneumonia of the left lung. Autopsy by Dr. Jacobsen revealed, among other things, extensive chronic interstitial pneumonitis of the right lung with adhesive pleuritis, bilateral bronchopneumonia and extensive bronchiectasis of the right lung. The case is cited to show the deleterious effects on the lung tissue and bronchi of large doses of deep x-ray therapy. Figure 16 is a sagittal section through the right lung showing extensive fibrosis and thickened pleura and bronchiectasis. Courtesy of Dr. Victor Jacobsen, Troy, New York.

should visualize in considering the morbidity and treatment of many patients with bronchiectasis. Unfortunately, the complete lobectomy on a young nurse, in fairly good general health, with right lower and middle lobe saccular bronchiectasis, who had

suffered a long period of invalidism, including social maladjustment and serious economic reverses, many of her patients not desiring her services because of chronic cough, severe halitosis and foul odor to the sputum, because at the time the patient was seen by the surgeons, the symptoms were comparatively mild—the optimum time for lobectomy.

In considering the morbidity of their living cases of medically treated bronchiectasis, Perry and King state that "most of the patients continue to have the same symptoms of cough, sputum and occasional hemoptysis. Often the amount of sputum increases and becomes foul in odor, though the patient mercifully may lose his appreciation of this fact through the loss of his sense of smell. He remains, however, unpleasant to relatives and friends, and suicide figuring twice in the causes of death in our series, indicates the patient's own unhappiness in living with his disease."

In assessing the "living capacity" of the nonsurgically treated group of their patients, the same authors estimated that "38 per cent were in excellent condition (despite the fact that more than 90 per cent continued to have cough and expectoration, and almost a third continued to have occasional hemoptyses), 42 per cent were in fair condition and 15 per cent in poor condition, with 5 per cent in extremely poor condition."

Despite these rather high percentages of patients in excellent to fair condition in this exceptionally well studied and large series of cases, it is well known that the condition of bronchiectasis patients ebbs and flows with the years and the seasons. In this connection, it might be mentioned that, while we agree in part with Perry and King that bronchiectasis, *per se*, rarely spreads to lobes other than those involved when the patient is first seen, nevertheless, we have frequently observed areas of fibrosis and suppurative pneumonitis enlarge and extend to previously uninvolved lung, and associated emphysematous changes become progressively worse. These fibrotic

and emphysematous changes not infrequently dominate the clinical picture. Since relapse and remission, progressive fibrosis or pneumonitis, emphysema, chronic toxemia and anoxemia, characterize the natural course of the disease, it is reasonable to assume that the observed morbidity and mortality of bronchiectasis become greater the longer the cases are under observation.

Estimating the morbidity of any group of chronically ill patients is difficult and hazardous, and at best, founded on impressions rather than scientific facts. Despite these handicaps, an appraisal of the one hundred cases of bronchiectasis observed at the Lenox Hill Hospital Clinic during the past ten years, has been attempted by studying the number of hospital admissions, the frequency and severity of respiratory infections, the attacks of bronchopneumonia and acute or subacute attacks of so-called bronchitis, and pleurisy, the occurrence of hemoptyses, miscellaneous related illnesses, chronic sinus disease, the ability of the patient to work, their psychological state and social adaptability, and finally, whether or not the disease remained unchanged, improved or became worse. While a statistical analysis of these data is impossible, nevertheless, a fairly definite impression based upon close and prolonged personal observation and supplemented by a detailed analysis, give one a fairly complete picture of the morbidity in this group of cases.

Readmission of many of these patients to the hospital ward for reasons related to their bronchiectasis, was generally quite frequent, and varied from one to seven times during the maximum observation period of ten years. The definite impression is gained that readmission to the hospital of our bronchiectasic cases, was considerably more frequent than was true of patients having pulmonary tuberculosis and treated in the same clinic. Respiratory infections, including so-called bronchitis, atypical and typical attacks of bronchopneumonia, occurred much more frequently in the group of bronchiectasic patients than

in the patients with tuberculosis. Many bronchiectasic patients had from three to five atypical or typical attacks of bronchopneumonia during the ten-year period. It is reasonable to assume, that others had mild attacks of bronchopneumonia without being admitted to the hospital. Hemoptysis, though usually not large in amount, was a frequent and disturbing symptom, and was often followed by febrile attacks, with increase in cough and expectoration and occasionally the development of foul odor to the sputum. So-called head colds, exacerbation of chronic sinusitis, pleurisy, and asthmatic and asthmatoid attacks occurred frequently and seriously interfered with their work or studies in school.

Both clinical and laboratory studies show that many of these patients are "under-par" and not uncommonly develop nonpulmonary conditions directly or indirectly related to their poor general health. It was of interest that one patient developed complete prolapse of the rectum, and several others, inguinal herniae, conditions apparently indirectly related to chronic and excessive cough.

The working ability or the desire to work on the part of many of these patients of this economic status, is difficult to evaluate with any degree of accuracy, especially when present day relief measures often provide these people with greater economic security than does the work which is available to them, and which is frequently interrupted during the winter and spring seasons by exacerbations of their symptoms or relapse of their disease. In the living and traced patients, approximately 25 per cent have been able to do full time work as a general rule, and 40 per cent have been able to do part time work, their work being frequently interrupted by relapse of the disease. The remaining 35 per cent were either unable to work at all because of the severity of their symptoms, or had given up the idea of economic rehabilitation because of the psychological effect of the disease. These various physical and psychological factors which constitute the morbidity of

the disease are undoubtedly responsible for the frequent failures in most of their endeavors of life. Little wonder that they become frustrated, depressed and are not over energetic or ambitious.

Churchill has forcefully emphasized the psychological handicap or morbidity of bronchiectasis. An appraisal of our patients in this regard reveals that this very important handicap was seldom properly evaluated by the physician and was frequently largely left to the social worker in the clinic or relief agency. In many patients, serious psychological handicaps undoubtedly play an important part in their social maladjustments, more especially those having chronic cough and foul odor to the sputum. The fact that 70 per cent of our adults are still single, and 6.6 per cent of those married are either divorced or separated, and that only 25 per cent are doing full time work, many of these their own housework, emphasizes the great importance of the psychological as well as physical morbidity which apparently caused three of our patients to threaten suicide. Seemingly it also was an important factor in the development of paranoia in another patient, necessitating hospitalization in a psychiatric institute, and led two of Perry and King's patients to commit suicide.

Thus, chronic invalidism beginning in childhood and often continuing throughout life, characterized by mental lethargy and inaptitude, physical unfitness and debility, and social maladjustment, is not infrequently the inevitable picture of many advanced, untreated and unsuccessfully medically treated cases of bronchiectasis. Indeed the morbidity in many cases of advanced bronchiectasis with suppurative pneumonitis, consisting of chronic invalidism, psychological changes ranging from mild depressive states to psychopathic personalities, complete economic insecurity, a life alone, apart, helpless and hopeless, is perhaps a greater problem for the internist, psychiatrist and surgeon than is the actual mortality of bronchiectasis, convincing as it is of the ultimate fate of

most patients with untreated and medically treated bronchiectasis. Little wonder that Churchill states that young adult patients rarely hesitate to elect a chance for cure if the possibility is offered. On the contrary, we regret with Churchill, that "Unfortunately, we still see the patient who returns to his family doctor for advice and is told that the operation (lobectomy) is an impossible one and that to consent to it means certain death."

An estimation of the present status of our untreated and medically treated living cases based on their symptoms, general and local conditions, shows that 13.3 per cent are regarded as improved, 46.6 per cent essentially unchanged and 41.1 per cent definitely worse than when first seen. We have not succeeded in curing any case of well developed bronchiectasis with medical measures including climatic treatment, x-ray therapy and bronchoscopy. The treatment of bronchiectasis is surgical, where major surgery is feasible and not contraindicated.

MORTALITY OF UNTREATED AND MEDICALLY TREATED BRONCHIECTASIS

While it is well known that many patients with extensive bronchiectasis may live out their normal span of life, it is also well recognized that this is an exception to the general rule. From reports in the literature and observations at Bellevue and Lenox Hill Hospitals, it is the impression that the majority of patients with bronchiectasis, succumb to some form of respiratory illness, or complication, either before or during the fourth or fifth decades.

Comparatively few large series of cases have been followed for sufficiently long periods of time, and for this reason, available comprehensive statistical studies of the mortality of the disease are somewhat limited. The reported mortality rates vary widely, depending upon the duration of observation, age at onset, type, extent, severity and location of the disease, and the predominant types of micro-organisms implicated. The prognosis in cases of relatively "dry" bronchiectasis involving the right upper or middle lobe with very little pulmonary fibrosis and emphysema, is relatively good in comparison with that of bilateral lower lobe saccular bronchiectasis with secondary anaërobic infection, extensive pulmonary fibrosis or suppurative pneumonitis.

In a group of forty-nine nonsurgically treated cases, observed for a period of six years, Roles and Todd report a mortality rate of twenty-three, or 47 per cent. This rate is considerably higher than that usually found in cases observed for similar periods of time. In Head's series of 200 cases, he found that of those having the onset during the first decade, but few were living after the age of forty. While our observations have been somewhat similar to those of Head, we have a considerable number of patients still living in their sixth and seventh decades, in whom the onset of bronchiectasis was in childhood.

G. E., male, aged seventy-six, has been under observation eleven years and gives a history suggesting the onset of his bronchiectasis at the age of five or six years. He has extensive bilateral cylindrical bronchiectasis involving both lower lobes with a moderate degree of pulmonary fibrosis and emphysema.

D. S., male, aged fifty-six, was under observation for eight years. He gave a history of repeated hemoptyses following "pneumonia" at the age of eight. When first seen ten years ago, he had saccular bronchiectasis involving the entire left lung with extensive pulmonary fibrosis resulting in marked displacement of the mediastinal structures to the left. Conventional serial chest roentgenograms over a period of twenty-one years, and lipiodol bronchography during a period of nine years, showed essentially no change of the pulmonary fibrosis or bronchiectasis. However, the patient finally succumbed to his pulmonary disease, dying of pneumonia at the age of sixty-four, after having had *known* saccular bronchiectasis for twenty-one years, and a history indicating that he had had bronchiectasis for a total of fifty-six years.

These isolated cases are of interest in that they indicate that occasionally pa-

tients with extensive bronchiectasis may live out the usual estimated life span, despite numerous relapses and exacerbations of the disease.

In their excellent paper on 400 cases of proved bronchiectasis, Perry and King report their findings regarding the natural course and prognosis of medically and surgically treated cases. They state that "A twelve-year study of the entire group showed the mortality in the nonsurgically treated cases 26 per cent, 41 per cent of these dying within five years of the onset and 15 per cent living twenty years or longer after the onset. Seventy-eight per cent of the dead died directly as the result of their disease." They state further that, "The working and living capacity of the traced living patients was considered to be excellent in 67 per cent of the surgical group and in 38 per cent of the nonsurgical group."

The estimated duration of the bronchiectasis of the entire series of cases (living and dead), observed at Lenox Hill Hospital, is 16.4 years. The average age of these patients is 35.8 years. The known mortality of the series collected during ten years with many being observed only for the past three or four years, is twelve or 12 per cent. However, fifteen patients or 15 per cent have not been traced during the past year and their status is unknown. The mortality for traced medically treated patients is 14.1 per cent.

TREATMENT

Remission and relapse, natural phenomena of the disease, should be borne in mind when attempting to evaluate the value of any form of therapy.

Since the etiology of bronchiectasis is dependent upon many factors, any attempt at prophylaxis must be on a general basis and essentially designed to build up the patient's resistance to infection and disease. The onset of bronchiectasis being most frequent during the first decade of life, the prevention of the disease devolves about the management of the usual diseases of

childhood, especially the exanthemas, pneumonia, and more especially, streptococcal and influenzal pneumonia, and is primarily a problem of the pediatrician.

Children unduly susceptible to respiratory diseases, especially frequent colds, acute bronchitis and bronchopneumonia, should have more careful observation than is usual. This should include longer periods of bed rest than are customarily given to patients with upper respiratory infections, and every effort to improve the general condition and increase resistance to infection. In addition to the usual measures taken to bring about this result, removal of the child to a warm, dry climate during the winter and spring seasons may be of great value. Climatic treatment for the extensive case of bronchiectasis is only palliative at best and should never be substituted for surgical treatment where this type of treatment is indicated and feasible.

The prompt removal of foreign bodies (Figs. 1 and 2), polyps and benign tumors (Figs. 5 and 6), is of great importance, if serious infection, frequently anaerobic in nature, with the subsequent development of bronchiectasis is to be prevented. Prompt and adequate treatment of lung abscess, including surgical drainage, aids in the prevention of residual bronchiectasis. Although prophylactic treatment of bronchiectasis at best has very definite limitations, nevertheless, the prevention of bronchiectasis is probably less difficult than its cure. Insofar as our present knowledge goes, there is no medical cure of well developed bronchiectasis. The only known cure is surgical extirpation of the diseased part of the lung.

During the past number of years, we have tried the usual methods of medical treatment, however, without any worth while success except for symptomatic improvement. These measures consist of postural drainage, usually three or four times daily, beginning with the early morning, and repeating again just before retiring, the usual efforts to improve the general condition and increase the resistance to

infection, occasionally, pneumothorax in cases of relatively dry hemoptoic bronchiectasis to control hemorrhage, heliotherapy in the form of ultra-violet light to the entire body during winter, occasionally, autogenous vaccines, sometimes combined with cold vaccine, with the hope of preventing or minimizing upper respiratory infections and colds, thereby preventing or diminishing their ill effects on the bronchiectasis. We have not given arsenicals, but have had patients who transferred to our clinic, who had received arsenicals elsewhere, apparently without any beneficial effect whatever.

X-ray Therapy. In 1934, Berck first advocated x-ray therapy for the treatment of bronchiectasis. In his report of a case, he stated that "The purpose of this communication is to state the rationale and report the results of radiotherapy in the treatment of a case of bronchorrhea in bronchiectasis." He postulated that "The purpose of the application of radiotherapy, briefly, is to render the hypertrophic, hypersecreting bronchial mucosa atrophic and thus converted a 'wet' bronchiectasis into a 'dry' bronchiectasis."

The assumption by Berck that "the hypertrophic hypersecreting bronchial mucosa" is the source of the purulent secretions in bronchiectasis with suppurative pneumonitis seems highly theoretical and contrary to the general conception of the origin of purulent secretions in bronchiectasis. It seems more logical to assume that such secretions are the product of suppurative pneumonitis and ulcerative bronchitis and bronchiectasis rather than the result of a hypersecreting hypertrophic bronchial mucosa. Often, the bronchial mucosa no longer exists as such in bronchiectasis, but may be largely replaced by chronically infected granulation tissue. Berck's theoretical reasons for x-ray therapy for bronchiectasis seem illogical and not founded on the gross pathology and pathological physiology of the disease. By 1939, Berck and Harris had largely abandoned their first theory explaining the rationale of x-ray

therapy for bronchiectasis and, at that time, offered a second theory. They state: "Further explanatory hypotheses may be adduced to explain the successful action of roentgen rays in suppurative bronchiectasis, such as, possible enhancement of immunity processes both through the action of the rays in stimulating antibody action, and the physico-chemical alterations of the local tissue reactions." They concluded in this report that roentgen therapy for suppurative bronchiectasis is both "feasible and successful."

Because of Berck's encouraging report of 1934, several patients with bronchiectasis were subjected to x-ray therapy. Most of the treated patients experienced mild to moderate exacerbation of their local pulmonary symptoms and some developed what appeared to be related febrile attacks while receiving treatment. Occasional patients also developed what appeared to be related temporary remission of symptoms following treatment. We have followed these patients with particular interest during the past few years and find that the natural course or behavior of their disease has been quite similar to that before x-ray treatment was begun. We have not observed lasting improvement in any case. On the contrary, we believe that this form of treatment may result in the development of further pneumonitis and irreversible fibrosis. The following case illustrates the potential and actual disadvantage and danger of roentgenotherapy in the treatment of bronchiectasis:

G. L., male, aged thirty-four, was admitted to the Lenox Hill Chest Clinic in 1934 with saccular bronchiectasis of the lower half of the left lower lobe, and cylindrical ectasia in the lingula of the left upper lobe. (Figs. 12 to 15.) Therapeutic bronchoscopy had been done over a period of many years before coming to our clinic, apparently without any improvement in his condition. Lobectomy was advised but refused. Roentgenotherapy was suggested and accepted. Before roentgenotherapy was begun, there was a moderate amount of fibrosis limited to the lower third of the left lung field. The

upper half of the left lung was normal on physical and roentgenological examinations. (Figs. 12 to 15.)

In the latter part of 1934, and in the summer of 1935, the patient was given two series of roentgen-ray treatments by the Radiological Department. Approximately 1,500 r were given through each of several portals, with a total of 6,000 r. Some of the treatments were inadvertently directed to the upper half or normal part of the left lung. A few days after receiving treatment over the upper half of the lung, the patient developed pain in the left upper chest, with a temperature rise to 101.6°F. and increased cough and expectoration. After admission to the hospital, the chest roentgenogram revealed a new area of clouding in the left upper half and also increased clouding in the left lower third. At first these changes were thought to be the result of bronchopneumonia. However, the persistence of the inflammatory changes in the left upper third, where there was no bronchiectasis, and their final conversion into fibrosis which persisted to some degree for over two years, or until the patient's death, convinced the staff that the condition was one of x-ray pneumonitis.

The fortuitous circumstance that resulted in the patient receiving considerable x-ray therapy over the left upper, or normal lung field, offered an opportunity to evaluate more accurately, the effect of such a dose of roentgenotherapy on a part of this patient's normal as well as diseased lung. Prior to this experience, evidence of increased pneumonitis, following x-ray therapy to bronchiectatic areas, was thought to be due to an exacerbation of the chronic pneumonitis. However, the above and other observations, and the work of Desjardins, Jacobsen and others, convinced us that roentgenotherapy, when the dose is sufficiently great and purposefully directed through several portals to converge on a selected area within the lung, may cause acute inflammation of the lung or pneumonitis. If the damage to the lung is sufficiently severe, permanent or irreversible fibrosis may result and actually aid in the development of bronchiectasis. This has been observed in a case reported by Jacobsen. (Fig. 16.)

Because roentgen therapy for bronchiectasis seems illogical, and having observed acute pneumonitis and irreversible fibrosis and emphysema develop in a considerable number of treated patients, and since such damage may lead to further bronchiectasis and adhesive pleuritis, making future thoracic surgery more difficult, it is believed that this method of treatment should be strongly discouraged.

Bronchoscopy. Diagnostic bronchoscopy is indicated in most cases with suspected or known bronchiectasis. However, it is most doubtful if therapeutic bronchoscopy is of any benefit except in a very limited number of patients, namely, those having foreign bodies in the bronchi, benign bronchial tumors, partial bronchial occlusion or stenosis of the stem bronchi.

Bronchoscopic lavage with various so-called "bactericidal" agents advocated by some bronchoscopists is not only useless but dangerous. Such treatment increases the amount and liquidity of infectious secretions and materially enhances aspiration of these secretions into relatively healthy areas of lung tissue. We have seen severe febrile reactions with the subsequent development of new areas of pneumonitis following bronchoscopic lavage. This type of treatment is useless and should be discouraged.

The failure of medical treatment of bronchiectasis, the protracted morbidity and high mortality, its tendency to localize in one or two lobes, have encouraged thoracic surgeons during the past number of years to perfect some successful method of treating the disease. Many recent reports of the successful surgical treatment of bronchiectasis and suppurative disease of the lung by Churchill, Overholt, Churchill and Beasley, Bohrer, Berry, O'Brien, Haight, Heuer, Walker and others, are convincing of the rapid advances made during the past few years in the surgical treatment of bronchiectasis.

In 1940, Perry and King reported that "the operative mortality in 122 modern type lobectomies performed on 116 patients

by Dr. Edward D. Churchill was 3.3 per cent." This exceedingly low mortality rate is convincing evidence that lobectomy for selected cases of bronchiectasis by experienced thoracic surgeons is not only a safe procedure but the best curative measure for bronchiectasis. Those who are content to continue with postural drainage, bronchoscopic lavage, vaccines, roentgenotherapy, climatic treatment, arsenicals, and are misled into believing that the natural temporary remission of symptoms is the result of these medical measures, cannot be aware of the natural behavior of the disease and the feasibility and curability of lobectomy in many cases of bronchiectasis.

CONCLUSIONS

1. Wide differences of opinion still exist regarding many aspects of bronchiectasis.

2. Congenital bronchiectasis is an extremely rare condition and is apparently frequently confused with acquired saccular bronchiectasis.

3. Bronchiectasis usually has its onset in childhood or early adult life. Chronic sinusitis usually has its onset relatively later in life.

4. Chronic disease of the paranasal sinuses is perhaps more often secondary to bronchiectasis than is bronchiectasis secondary to paranasal sinus disease.

5. There is no satisfactory medical treatment or cure for bronchiectasis. However, certain medical measures may aid symptomatic improvement.

6. The morbidity and mortality of untreated and medically treated bronchiectasis and suppurative pneumonitis is such that the physician who routinely advises young adults with operable bronchiectasis against surgery, is assuming a grave responsibility and in all probability renders his patient a great disservice.

7. Most patients with bronchiectasis and suppurative pneumonitis should be considered for lobectomy or pneumonectomy although many may be found inoperable.

8. Modern lobectomy by experienced thoracic surgeons is a safe and curative procedure for bronchiectasis.

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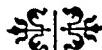
PULMONARY CYSTS*

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THE terms, "pulmonary cyst" and "cystic disease of the lung," have been applied to a wide variety of pathological processes in the lung. Some authors include in the category of cysts all sizeable fluid or air-containing cavities within the lung that are not primarily the result of destruction of pulmonary tissue by suppuration or caseation. Other authors use the term, "cystic disease of the lung," as synonymous with "congenital cystic disease," thereby inferring that all pulmonary cysts are congenital. Some cases that have been reported as examples of cystic disease of the lung, however, have been acquired lesions. As a result, there is much confusion in the literature concerning terminology, and authors are in disagreement as to what conditions should be included as pulmonary cysts.

The usage of the term, "pulmonary cyst," without qualification for a wide variety of intrapulmonary air-containing cavities is unsatisfactory. Although at the present time it is sometimes not possible to determine clinically the exact nature of the cavity present in a given case, attempts should be made to differentiate the various types on the basis of etiology and pathology. The mechanics of the cavity formation and the structural characteristics of the cavity wall determine the distinctive clinical features of the various types of cyst-like pulmonary conditions. Rational treatment can be applied only when the factors which differentiate the various types of lesions are evaluated.

The formation of a cavity in the lung depends on either (1) developmental abnormality, (2) destruction of pulmonary tissue by an inflammatory process, or (3) hyperinflation of a small defect in the pulmonary parenchyma, or a combination of these processes. Persistence of intrapulmonary cavities may be due to one or more of the following factors: (1) positive intracavitary pressure, (2) progressive destructive process within the lung, (3) loss of expansibility of surrounding pulmonary tissue, (4) elastic properties of the cavity wall, or (5) epithelization of the cavity wall.

The various factors just enumerated determine whether a given pulmonary cavity is likely to disappear spontaneously, whether the cavity can obliterate itself after drainage or whether excision of pulmonary tissue is necessary. A cavity which owes its size chiefly to hyperinflation by a check-valve mechanism of the communicating bronchus may have a different clinical course than a cavity produced by destruction of pulmonary tissue. Decompression or drainage may be all that is required for the disappearance of a nonepithelized cavity if the surrounding lung is elastic, but drainage alone will not result in obliteration of a cavity completely lined by epithelium even though the adjacent pulmonary tissue is normal.

The following types of lesions have been included under the term of pulmonary cyst by some authors:

I. *Nonparasitic Cysts and Cystlike Cavities:* 1. Congenital pulmonary cysts: congenital fluid or air-containing cavities in the lung which may or may not have an epithelial lining. The cysts may become expansile because of positive intracavitary pressure. The lesions are due to developmental defects or intrauterine disease, but secondary infection may be superimposed.

2. Cystic bronchiectasis: cyst-like dilatation of the bronchi which may be congenital or acquired.

3. Acquired intrapulmonary cavities originally produced by the destruction of

pulmonary tissue. The cavity may or may not be epithelized.

4. Pneumatoceles: nonepithelized posi-

Fig. 1. Large infected pulmonary cyst in a four-year old child which was treated as an empyema for two years. Cyst successfully removed after diagnosis was established by biopsy of cyst wall which revealed lining of stratified columnar epithelium.

tive pressure cavities produced by the hyperinflation of a defect in the pulmonary parenchyma resulting from pulmonary infection.

5. Emphysematous bullae: nonepithelized pulmonary cavities produced chiefly by the disruption of interalveolar septa.

6. Pulmonary blebs: localized collections of air within the pulmonary interstitial tissue.

II. *Parasitic Cysts.*

CONGENITAL PULMONARY CYSTS

Various pulmonary lesions have been classified in the literature as congenital cysts of the lung or congenital cystic disease. In some such instances the congenital origin of the lesion is either open to question or the lesion is definitely an acquired one. It is often impossible to ascertain definitely on the basis of the history and a single roentgenogram whether the cystic disease is congenital or acquired. This applies to children as well as adults. A series of roentgenograms may aid in the

solution of the problem by demonstrating changes which are inconsistent with one or the other type. In some instances the sus-

Fig. 2. Huge pulmonary cyst simulating a tension pyopneumothorax. Note strand of tissue extending out from pulmonary hilar region and traversing cavity. (Fig. 3.) There is considerable mediastinal displacement. Prolonged drainage resulted in little diminution in size of cavity.

pected congenital nature of the cyst has been disproved by the chance existence of a previous roentgenogram demonstrating no pulmonary abnormality.[10] It must be realized that infection and mechanical derangement in the lung may result in the formation of huge intrapulmonary air cavities. These pneumatoceles and emphysematous bullae frequently cannot be differentiated radiographically from congenital cysts of the lung. The problem is not merely of academic interest because the behavior of congenital and acquired cysts differs somewhat and the treatment may, therefore, be altered.

Congenital cysts of the lung may be fluid or air-containing and may be single or multiple. The size of the cysts varies markedly. It has been assumed by some authors that all the air-containing cysts were originally fluid cysts which later ruptured into a bronchus. Following the discharge of the fluid contents, air entered the cyst cavity. The frequency of this sequence of events cannot be established on the

basis of the data available at present, but it seems to be an uncommon occurrence.

Congenital cysts may be lined by a

FIG. 3 Photomicrograph of cross-section of strand of tissue traversing cavity in Figure 2. There is a complete covering of stratified columnar epithelium and the cord-like strand contains bronchi. These findings indicate that cavity is intrapulmonary.

cylindrical, cuboidal or flattened epithelium or the cyst may have no definite epithelial lining. The epithelium may be destroyed by secondary infection. Some of the cysts, but especially those without an epithelial lining, may become inflated to a huge size by a check-valve mechanism of the communicating bronchus.

Koontz[8] in 1925 could find only 108 cases of congenital cysts of the lung in the literature. Included in this group were a few cases of conditions such as diverticula of the trachea or main bronchi, solitary cysts of the tracheal or bronchial wall, and cysts of aberrant lung tissue and accessory lobes. Moreover, it is impossible to be sure that all of the pulmonary lesions were congenital in origin. The paper by Koontz stimulated interest in the subject and a large number of reports have appeared since.[13] In 1937, Schenck[12] collected 381 cases of congenital cystic disease of the lung from the literature, but the congenital

nature of the cysts in some cases is open to question. Schenck[12] studied the incidence of the various types of cysts. In 38 per cent of the cases the cysts were solitary and in 62 per cent multiple. In 23 per cent of the cases solitary or multiple fluid cysts were present and in the other cases air cysts were found. Somewhat less than half of the cases were observed in infancy and childhood. Congenital cystic disease of the lung may be associated with other congenital anomalies. Cystic disease may be found in aberrant intrathoracic lung tissue.[5]

Congenital pulmonary cysts may cause symptoms shortly after birth or in childhood, but in some instances there are no pulmonary symptoms until adult life or the pulmonary cysts are unexpected roentgen or autopsy findings. The most common symptoms are cough, dyspnea and expectoration. Recurring attacks of dyspnea and cyanosis are common in infants. Fever, hemoptysis and thoracic pain may be present, especially in adults. Dyspnea and cyanosis are most prominent in the positive pressure air cysts.

The fluid-containing congenital pulmonary cysts usually cause no symptoms until secondary infection occurs. If the cyst is

cavities appear as round or oval areas of increased radiolucency. The location and contour of the area of radiolucency may
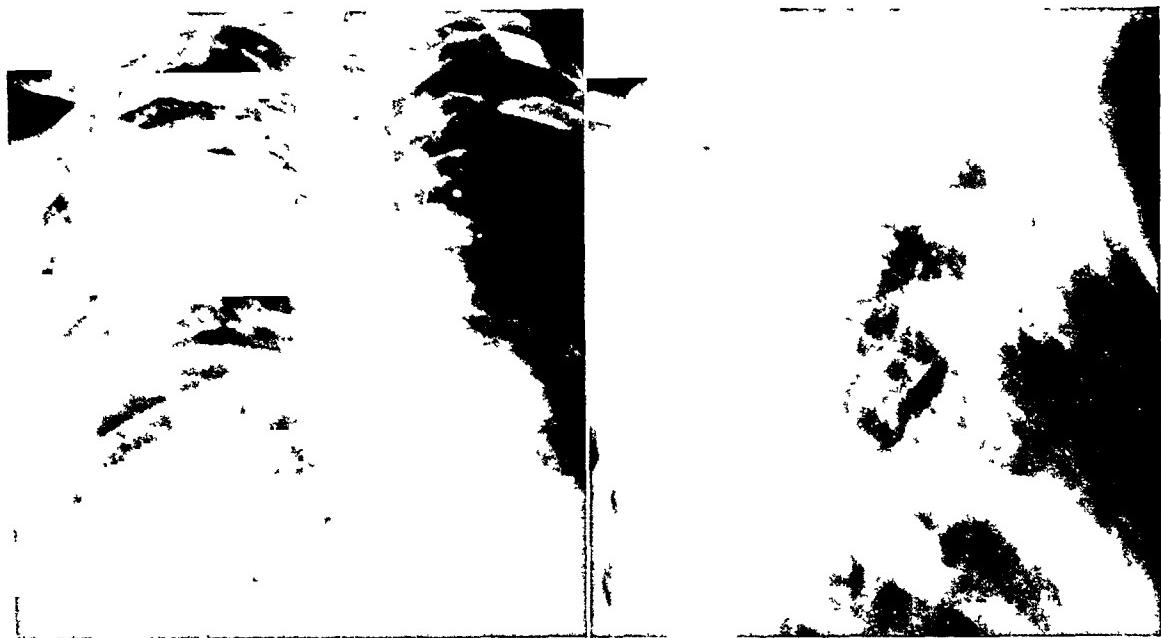
Fig. 4. Large infected intrapulmonary cavity in an adult. Following thoracotomy with drainage the cavity obliterated completely. Biopsy showed no epithelial lining.

large or if there are multiple cysts, dyspnea may be present. When the fluid cyst ruptures into a bronchus, an air cyst may simply result,[1] or the cyst may become filled with pus. Infected solitary pulmonary cysts, whether congenital or acquired, may simulate a pulmonary abscess or an encapsulated empyema. (Fig. 1.)

Air cysts may be asymptomatic, but not infrequently due to a check-valve mechanism of the communicating bronchus the cyst becomes hyperinflated and may assume a huge size. These positive pressure cysts may compress the adjacent pulmonary tissue to a marked degree so that dyspnea and cyanosis may result. These balloon cysts may encroach on the remaining pulmonary tissue to a sufficient degree to cause death due to respiratory insufficiency.

The physical signs vary and are rarely diagnostic. The roentgenographic findings are the most important clinical evidence in the diagnosis of pulmonary cysts. The fluid cysts appear on the roentgenogram as round or oval areas of increased density. If the cyst communicates with a bronchus, a fluid level may be present. The air-filled

serve to differentiate an intrapulmonary cavity from a localized pneumothorax. In expansile cysts there may be evidence of compression of the surrounding pulmonary parenchyma. The large positive pressure cysts may occupy almost an entire hemithorax and may even displace the mediastinum markedly toward the opposite side. (Fig. 2.) This latter type of cyst is frequently incorrectly diagnosed as a tension pneumothorax. The two conditions can usually be differentiated radiographically, however, because in the case of a huge cyst there is no prominence at the pulmonary hilum representing collapsed lung, and the costophrenic sinus contains compressed pulmonary tissue.

The treatment of congenital cystic disease of the lung depends on the character and distribution of the lesions. The importance of differentiating congenital cysts from acquired nonepithelized intrapulmonary cavities such as pneumatoceles, which may disappear spontaneously, should be borne in mind. Occasionally large fluid cysts disappear spontaneously.[2] Expansile air cysts may present a serious problem in

infancy. Due to progressive enlargement of the cyst, the normal lung is encroached upon and serious or even fatal respiratory the uncollapsed cyst. Moreover, aspiration may give very transient relief due to the rapidity with which the air re-accumulated
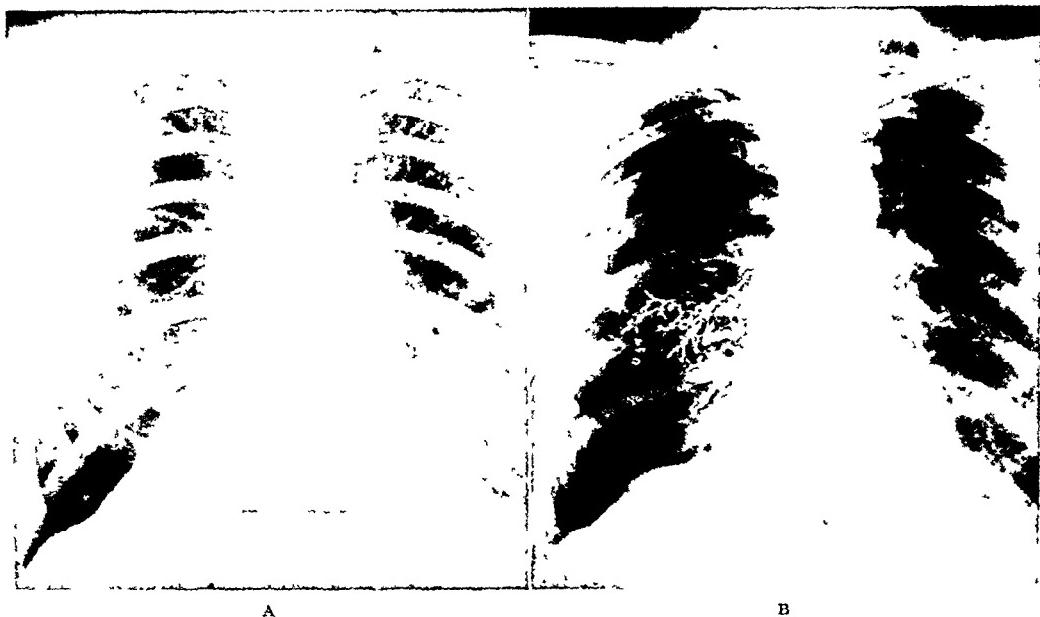
FIG. 5. Bronchiectasis with bullous emphysema of right lower lobe. A, large and small bullae in costophrenic sulcus; B, bronchogram shows saccular bronchiectasis of right lower lobe. Some pneumothorax is present.

difficulties may ensue. Attempts to deflate large balloon cysts by aspirating the contained air have been made repeatedly. The procedure is a dangerous one because in the case of the congenital cysts, particularly in infants and children, the pleural space is often not obliterated. Therefore, after the aspiration of air from the cyst, there is frequently leakage of air into the pleural space. A tension pneumothorax often results. If the patient's respiratory reserve has already been seriously encroached upon by the compression of pulmonary tissue by the cysts, the tension pneumothorax may prove fatal unless it is immediately controlled. It should not be assumed that, as the air leaks out of the hole in the cyst wall into the pleural space, the cyst will necessarily collapse. The defect in the cyst wall may also act like a check-valve mechanism and permit air to leak into the pleural space during inspiration but less readily permit air to re-enter the cyst from the pleural space during expiration. Therefore, the tension pneumothorax may merely displace in the cavity because of the check-valve bronchial communications. Occasionally closed tube drainage is satisfactory. A few large expansile cysts have been treated successfully by lobectomy or pneumonectomy in childhood. Infected cysts should be drained. Sometimes the visceral and parietal pleura are not agglutinated even over a large cyst which extends close to the chest wall, and, therefore, steps must be taken to avoid pleural contamination at the time of thoracotomy. Following drainage the cavity may or may not become obliterated. If an epithelial lining is present, this lining must be destroyed before the cavity will disappear. Many of these latter cases require removal of the cyst wall or lobectomy. In some cases the infection may destroy the cyst wall and obliteration result. Destruction of the cyst wall by caustics has occasionally been successful.

In cases of multiple cysts in one lobe or even in one entire lung, lobectomy and occasionally pneumonectomy is indicated. Large infected solitary cysts of the lung

are often erroneously diagnosed as encapsulated empyema before operation, and at times the true condition is not recognized

pleura alone in cases of chronic empyema. If the infected cyst cavity is for the most part filled with air, the roentgenogram may
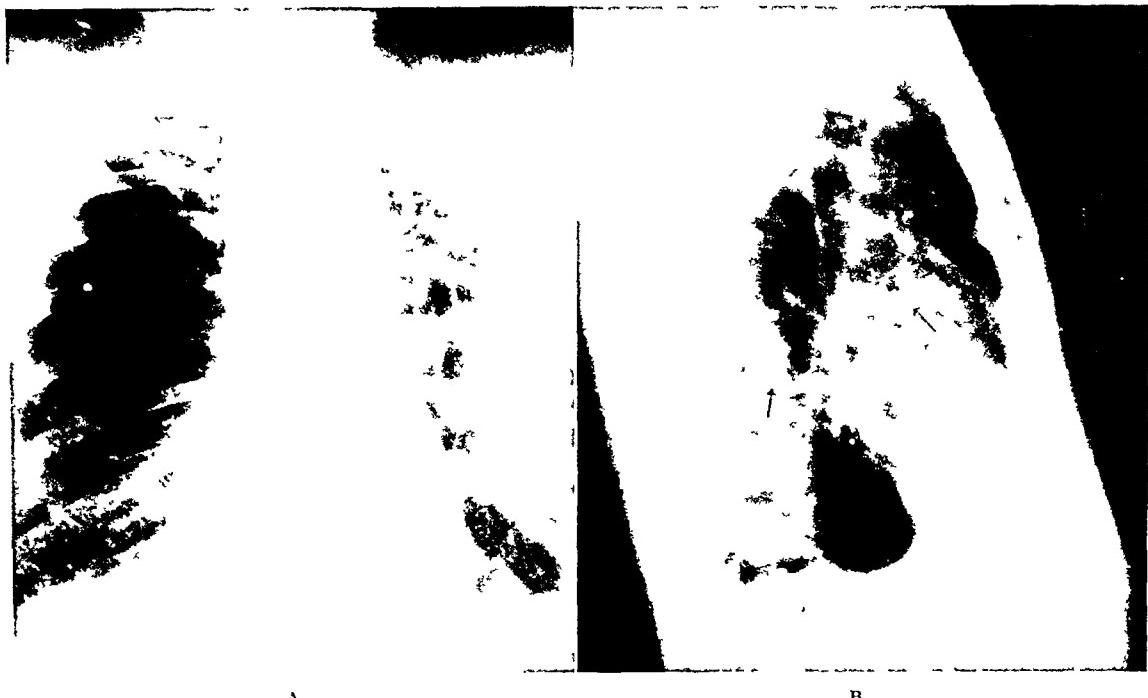
Fig. 6. Huge intrapulmonary air cavity in patient with chronic pulmonary tuberculosis and pulmonary fibrosis and emphysema. A, postero-anterior roentgenogram shows absence of pulmonary markings in large part of right lung field; B, outline of cyst-like space is indicated by arrows on lateral film.

during or after operation.[9] A striking characteristic of an epithelized pulmonary cyst is its failure to diminish appreciably in size over long periods of time despite adequate drainage. The roentgenologic examination is frequently of great aid in the differentiation of empyema and infected pulmonary cysts, but the two lesions cannot be distinguished by this means in some cases. The contour of the fluid pocket is often of differential diagnostic value in that the outline of a cyst is spherical or oval in both postero-anterior and lateral projections, whereas the outline of an encapsulated empyema may be triangular or fusiform and conforms more to the contour of the thoracic cage or neighboring structures in the region it occupies. Little evidence of pleural thickening may be seen on the roentgenogram of a person with a pulmonary cyst even though the infection is of many months' standing. The combined thickness of the cyst wall and pleura may be less than the thickening of the parietal

show strands of pulmonary tissue traversing the cavity, and the correct diagnosis should then be suspected. The presence of other pulmonary cysts, either fluid or air-containing, may give a clue to the correct diagnosis. It must be remembered, however, that an infected pulmonary cyst and empyema may co-exist.

At operation an absence of periosteal reaction on the inner surface of the overlying ribs may be noted in the case of an infected pulmonary cyst. This differential point is of greater significance if the infection has been present for a considerable length of time. Instead of finding the thickened parietal pleura characteristic of an empyema, the pleura may be quite thin. It may be noted that the pulmonary tissue is traversed in reaching the pus; but this finding does not necessarily mean that one is dealing with an intrapulmonary process because the approach to an encapsulated empyema may be through pulmonary tissue if an improper drainage site is

chosen, or if the empyema does not extend to the thoracic wall. Pulmonary tissue may be present or absent in the outer wall. If
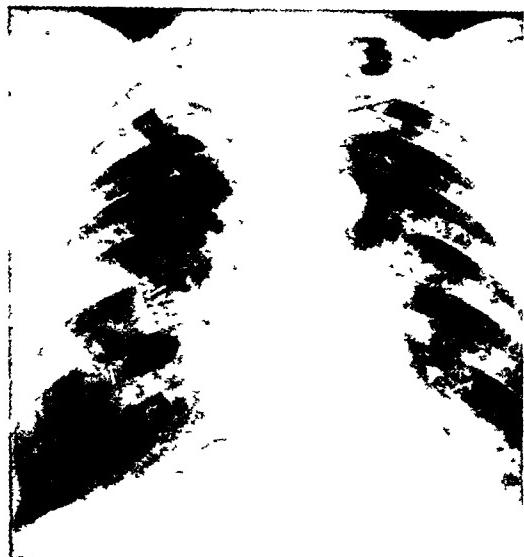
FIG. 7. Pneumatocele in adult with pneumonitis. Arrows indicate air cavity with thin wall.

present, it may be so thin that it can be recognized only microscopically. A biopsy will usually definitely establish the correct diagnosis. The wall of the bronchiogenic type of pulmonary cyst is usually lined by ciliated columnar epithelium, perhaps with areas of squamous metaplasia, and it may contain glands, smooth muscles, elastic tissue, lymph follicles and cartilage. However, infection in a pulmonary cyst may cause destruction of the epithelial lining, so that in such instances a biopsy which does not show characteristic tissue does not rule out the possible existence of a pulmonary cyst.

At the time of drainage of a pulmonary cyst it may be noted that a portion of a cavity wall has the appearance of a lattice lung with multiple bronchial fistulas. The presence of many small bronchial fistulas on the inner surface of the cavity wall should be regarded with suspicion, although many fistulas may be present in an empyema with an associated pulmonary abscess which has ruptured into the pleural space. In cysts with the appearance of a lattice lung, cord-like strands sometimes extend across the cavity. These cord-like

structures resemble the septa which are seen in multiloculated pulmonary abscesses, or the adhesions which contain pulmonary tissue in cases of pulmonary tuberculosis with pneumothorax. If a biopsy of one of these strands shows it to be covered completely by respiratory type of epithelium, the intrapulmonary nature of the lesion is demonstrated. (Fig. 3.)

If the true nature of the condition is not recognized at the time of the original drainage and the case is treated as an empyema, a striking feature in the postoperative course is the failure of the cavity to diminish progressively in size despite adequate drainage for months or years and without the presence of markedly thickened pleura. An initial decrease in size usually occurs due to the fact that the contents of the cavity were under pressure before drainage was instituted. The cavity of a pulmonary cyst will maintain its spherical or oval shape after drainage in contrast to the usual elongated shape of an empyema cavity. Associated with the failure of the cavity to collapse, any mediastinal displacement to the contralateral side which was present before surgical drainage may remain to a greater or less extent. The diaphragm may not become elevated as it tends to in the healing of an empyema cavity. The smooth, shining wall of the cyst is also in contrast to the fibrotic or granulating surface of the interior of an empyema. A bronchogram following drainage of a cyst may be of aid in the differential diagnosis.

Treatment of large infected pulmonary cysts with an epithelial lining should consist first of surgical drainage of the purulent contents by thoracotomy. In cases of suspected cyst, a rib resection rather than an intercostal type of drainage should be done to enable the operator to visualize the interior of the cavity and to secure a biopsy. If the first biopsy specimen is inconclusive, another more satisfactory specimen should be obtained. With subsidence of the inflammatory process in the cyst, the smoothness of the lining wall may be-

come more apparent grossly and the biopsy examination more satisfactory.

Several reports in the literature mention unsuccessful attempts to obliterate the large cavity which persists after drainage by various forms of collapse procedures, such as thoracoplasty and phrenicectomy. Collapse procedures are definitely contra-indicated as the primary method of treatment in the obliteration of these cavities; healthy lung will be sacrificed, and an incomplete collapse of the cyst will result.

The only procedures which result in obliteration of the pulmonary cavity are those which destroy or remove the epithelial lining. Chemical or electrosurgical cauterization of the epithelium are rarely effective. Furthermore, this method does not seem practical if numerous free bronchial communications are present and if there is a well developed epithelized wall with muscle and elastic tissue.

Removal of the cyst wall is the most certain method of treating the epithelized pulmonary cyst. This may be done by removal of the lobe containing the cyst or by enucleation of the cyst itself. If no definite line of cleavage around the cyst is present, lobectomy is the preferable procedure; otherwise, serious bleeding or air embolism may result. Lobectomy may be technically more difficult than the usual lobectomy for bronchiectasis. Anomalous vessels of large size, especially branches penetrating the diaphragm, may be encountered. The patients are usually children or young adults, and they are, therefore, at an age period when major intrathoracic procedures are borne well. With the infected contents of the cyst drained, ample time should be taken to permit subsidence of the inflammatory reaction and to improve the patient's general condition before radical surgery is employed.

CYSTIC BRONCHIECTASIS

Cystic bronchiectasis is included under pulmonary cysts by many authors. Some classify bronchiectasis as one form of con-genital cystic disease of the lung. Yet, we definitely know that cystic bronchiectasis may also be an acquired lesion secondary to bronchial obstruction by tumor or other process. It would seem best to classify cystic bronchiectasis as a form of bronchiectasis rather than consider the lesion as a type of pulmonary cyst.

Cystic bronchiectasis is treated similarly to other types of bronchiectasis. Lobectomy or pneumonectomy is indicated if the process is not too wide spread to warrant surgical excision of the involved areas. If untreated, the prognosis is not good because the extensive structural changes in the lung leave a fertile field for secondary infection. In some cases, however, the symptoms may be relatively slight for long periods of time.

ACQUIRED INTRAPULMONARY CAVITIES ORIGINALLY PRODUCED BY INFECTION

Cavitation in the lung parenchyma may remain indefinitely in cases of pulmonary suppuration even after the infection has subsided. The long persistence of the cavity of a pulmonary abscess after subsidence of the inflammatory process is usually due to the fibrosis of the adjacent lung, but is occasionally caused by the ingrowth of epithelium into the cavity from the communicating bronchi. The cavity may be lined by cuboidal, columnar or metaplastic squamous epithelium. The epithelization of the cavity may be partial or complete. A similar process may sometimes occur in an old tuberculous cavity in which the active tuberculous involvement has disappeared. Histological examination of a portion of the cavity wall is necessary to demonstrate whether epithelization of the cavity has occurred. A nonepithelized cavity remaining after pulmonary suppuration may have similar clinical findings.

If the patient has been studied radiographically during the course of the acute pulmonary suppuration, the origin of the intrapulmonary cavity may be readily evident. In such cases the typical roentgen findings of a pulmonary abscess cavity

with a fluid level and surrounding pulmonary infiltration may have been observed. With improvement of the infection the cavity may become empty and the surrounding infiltration clear. Whereas in most instances the cavity progressively diminishes in size as the infection subsides, in occasional cases the cavity persists. This is most likely to occur in cases of chronic lung abscess or in those cases in which there is considerable fibrosis of the adjacent pulmonary tissue which interferes with expansion of the surrounding lung. Epithelium may extend from the communicating bronchi into this persisting cavity. The epithelization then in turn prevents cavity obliteration. This process may occur both in pulmonary abscesses which have subsided through bronchial drainage or following surgical drainage of the purulent contents.

If the patient is first observed after the cavity has become empty of pus and the surrounding pulmonary infiltration has disappeared, it may be difficult to determine the mode of development of the cavity. It is under such circumstances that confusion with congenital cysts may arise. It may be erroneously assumed that the infection was superimposed on a preexisting congenital pulmonary cyst. (Fig. 4.) At times it may be difficult or impossible to differentiate roentgenographically an epithelized cavity from a pneumatocele. The former, however, usually has a thicker wall and does not change much in size, whereas the latter has a thin wall and may fluctuate considerably in size or disappear.

The epithelized cavity *per se* requires no treatment. At any time, however, the cavity may become re-infected through its bronchial communication. The pulmonary tissue surrounding such cavities, moreover, is usually chronically diseased. Pulmonary fibrosis, emphysema and bronchiectasis are frequently present. For these reasons, lobectomy or pneumonectomy is often indicated. Drainage of the cavity alone will not result in healing unless the secondary infection destroys the epithelial lining. It is rarely feasible to excise the cavity wall or destroy the epithelium by cautery or caustics.

EMPHYSEMATOUS BULLAE

In pulmonary emphysema there is fragmentation of the elastic tissue with rupture of the interalveolar septa. In most cases of pulmonary emphysema the number of alveolar septa which rupture in a given area is sufficient to produce only a small cavity. The disruption of the interalveolar septa may be fairly uniform throughout the lung although there is a tendency for the process to be pronounced in certain areas, especially along the border of the lung and in the pulmonary apices. In cases of diffuse emphysema, the roentgenogram shows increased radiolucency throughout the pulmonary field. If, on the other hand, extensive disruption of the interalveolar septa occurs in a localized portion of the lung, a large cavity, called a bulla, is produced. (Fig. 5.)

Obstruction to the egress of air from an emphysematous area in the lung probably plays a rôle in the development of an emphysematous bulla as it does in the formation of a pneumatocele. In the case of the emphysematous bulla this increased intracavitary pressure is transient as during coughing. If the cavity constantly had a positive intracavitary pressure, we would classify the lesion as a pneumatocele even though it occurred in an emphysematous lung. The reason for the distinction is that therapeutic measures of a deflating type would be of value only if positive intracavity pressure existed.

One or more such bullae may be present. The cavity is lined by the walls of the surrounding alveoli and there is no true epithelial lining. The bullous cavity has a rather poor communication with the bronchial tree by means of one or more small bronchi. The bulla shows on the roentgenogram as an area of even greater radiolucency than the surrounding emphysematous lung. If the bulla is large, there may be an absence of pulmonary markings

in that region. In some instances the outline of the bulla may be clearly defined on the roentgenogram, but frequently the borders are indistinct, at least in certain projections. (Fig. 6.) Emphysematous bullae are, therefore, an advanced form of emphysema, and it seems more appropriate to employ the term emphysematous bulla rather than call a large bulla a pulmonary cyst. Emphysematous bullae have to be differentiated from localized pneumothorax, pulmonary blebs and pneumatoceles. The differentiation of an emphysematous bulla and a localized pneumothorax is frequently difficult. The history and physical findings are usually of little aid. The roentgenogram is of greatest help. The outline of the bulla is round or oval and it may not extend to the chest wall as a pneumothorax does. In certain projections, especially the lateral view, the outline of the air cavity may be clearly defined as a thin line. Although it is impossible to draw a definite line of distinction between emphysematous bullae and pneumatoceles, attempts should be made to differentiate the two conditions. If the intrapulmonary air cavity is produced chiefly or entirely by the disruption of interalveolar septa and inflation of the cavity by a check-valve mechanism in the bronchus is absent or plays a minor rôle, the lesion is classified as an emphysematous bulla. If, on the other hand, the size of the cavity is largely due to hyperinflation of an originally small cavity produced by disruption of a few interalveolar septa or a small area of pulmonary destruction, the lesion is classified as a pneumatocele. The differentiation of bullae and pneumatoceles is of practical importance in a consideration of the clinical course of treatment. As a result of the different mechanics of the two conditions, emphysematous bullae do not disappear but tend to increase slowly in size, while pneumatoceles may rapidly increase or diminish in size and not infrequently disappear completely and spontaneously.

Kaltreider and Fray[7] studied the pathological physiology of the lungs in six patients with air-filled pulmonary cavities. The patients had pulmonary fibrosis and emphysema with emphysematous bullae of varying size. In half of the cases the total lung capacity, as well as the vital capacity was reduced while the residual air was only slightly increased. These findings indicate that in these cases the volume of the cyst is not included to a significant degree in the residual air. Therefore, the emphysematous bullae were poorly ventilated because of poor communication with the bronchial tree. In the remaining cases there was a marked decrease in vital capacity and a corresponding increase in the residual air with a relatively normal total capacity. The findings in these latter cases are typical of those of obstructive pulmonary emphysema.

The treatment of bullous emphysema is unsatisfactory. As it is a part of pulmonary emphysema and fibrosis, the involvement of the lungs is usually widespread. The patient may have dyspnea and even cyanosis. Sometimes there is marked respiratory insufficiency. Secondary to the pulmonary fibrosis there is hypertension of the pulmonary circuit and frequently right ventricular hypertrophy. Needling of emphysematous bullae is dangerous because a tear in the thin wall of the bulla may cause a tension pneumothorax.

Although emphysematous bullae have been discussed in this paper on pulmonary cysts we have done so chiefly in order to point out the difference between a bulla and other lesions which may have been classified as pulmonary cysts. It seems best to consider an emphysematous bulla as a locally advanced stage of pulmonary emphysema rather than call the bulla a cyst after it attains a certain size.

PULMONARY BLEBS

Pulmonary blebs are collections of air in the interstitial tissues of the lung. The air is localized in the interlobular connective tissue and just beneath the pleura. Pulmonary blebs are caused by the rupture of alveoli and the dissection of air

along the tissue planes of the lung. The pulmonary bleb may rupture and cause a pneumothorax. There may be associated mediastinal emphysema due to the dissection of air through the pulmonary hilum into the mediastinum. The process is acute and usually can be easily differentiated from other types of cyst-like spaces in the lung.

PNEUMATOCELES

A pneumatocele is a hyperinflated intrapulmonary cavity produced by the marked distention of a defect in the pulmonary parenchyma. The pneumatocele follows an interstitial pneumonitis with an inflammatory involvement of a small branch bronchus. As a result of the inflammatory narrowing of the bronchus a check-valve mechanism is produced and the pulmonary segment which communicates with the obstructed bronchus or bronchiole is tremendously dilated. (Fig. 7.) There is some disruption and destruction of the interalveolar septa both as a result of the increased intra-alveolar pressure and as a result of the interstitial inflammation. The degree of rupture of interalveolar septa is probably influenced by the elastic property of the lung. If the inflammatory process has occurred in the lung of a child and the elastic qualities of the lung were normal before the infection, there would be less fragmentation of interalveolar septa. If the pneumatocele occurs in a lung which has already lost some of its elasticity due to emphysema, rupture of interalveolar septa would probably play a greater rôle in the production of the pneumatocele. In support of this contention it may be pointed out that pneumatoceles may disappear more quickly in infants and children than in adults.

There is no definite line of distinction between a pulmonary abscess cavity and a pneumatocele. In a pulmonary abscess the cavity produced is chiefly caused by the necrosis and liquifaction of a somewhat comparable amount of pulmonary tissue. The rounded contour of the cavity is

partly determined by the elastic qualities of the adjacent pulmonary tissue. In some cases of pulmonary suppuration in which cavitation is present, there is no close correlation between the size of the pulmonary cavities seen on the roentgenograms and the amount of pulmonary tissue which has undergone necrosis. A small abscess cavity may become inflated by a check-valve mechanism of the bronchus into a large cavity. Therefore, a small area of pulmonary necrosis may produce a small cavity which is then inflated to a large size. It may be difficult to judge how much pulmonary destruction has occurred. This type of process seems to be considerably more common in cases of aerobic pulmonary infection than in anaerobic infections. In the latter group there is likely to be more rapid and extensive pulmonary destruction. Inflation of small areas of pulmonary excavation into large cavities is probably seen in a higher percentage of cases of pulmonary infection in infants and children than in adults.

These cases frequently run a somewhat characteristic course. The child has an acute respiratory infection with cough and fever. Roentgenograms show areas of consolidation. The cough may or may not be productive. On serial roentgenograms one ro more cavities of varying size may appear in the area of pulmonary infiltration. A large cavity may appear within a few days without the expectoration of any significant amount of sputum. In other words there is no clinical evidence to suggest the necrosis and liquifaction of considerable pulmonary tissue in a few days. The cavity may be entirely air-containing or a fluid level may be present due to the presence of both air and fluid in the cavity. Usually the fluid level is rather low; the presence of a high fluid level in the cavity would speak more in favor of pulmonary suppuration playing a more prominent rôle than hyperinflation. Frequently the finding of the cavitation is a surprise to the clinician because not infrequently the clinical signs of pulmonary infection may already be

slight at this time. Another roentgenogram taken a few days later may show marked enlargement in the size of the cavity. By this time the patient may be afebrile and almost free of pulmonary symptoms. If there is some cough present, it is usually productive of little sputum. In other words the clinical picture is rather inconsistent with a large acute pulmonary abscess. At this time the radiologist reports the presence of a large abscess cavity. In view of the rapid increase in size of the cavity as seen on the roentgenogram it may be concluded that rapid destruction of pulmonary tissue is taking place and surgical drainage may be considered advisable. The clinical significance of a large intrapulmonary cavity produced by tissue necrosis is very different from a large cavity which owes its size to hyperinflation. Pneumatoceles do not require surgical drainage. The correlation of the clinical course with the serial roentgenographic findings will usually permit a proper differentiation.

In infants and children especially, pneumatoceles may attain huge size. One or more pneumatoceles may occupy almost an entire hemithorax and markedly compress the surrounding pulmonary tissue. Peirce and Dirkse[10] have followed the course of such pneumatoceles over a period of time. Some pneumatoceles may disappear in a few weeks while others persist and often fluctuate in size over a period of months or years, although the patient is asymptomatic. The pneumatocele may disappear spontaneously after it has been present for months or even years. At any time while the pneumatocele is present, however, a flare-up of the pulmonary infection may occur.

A pneumatocele usually requires no surgical treatment in contrast to congenital pulmonary cysts and huge abscess cavities from which it must be differentiated. Extirpation of a lobe or the entire lung has been performed in a few cases of pneumatocele, but the advisability of lobectomy or pneumonectomy seems questionable if the

lesion is truly a pneumatocele. It is only if persistent marked compression of adjacent pulmonary tissue causes respiratory difficulty that surgical therapy is warranted. Then decompression of the pneumatocele, performed in such a way as to avoid a tension pneumothorax, is indicated. Intracavity suction by catheter may be satisfactory.

Caffey[3] has stressed the importance of differentiation of the cavitation of a pulmonary abscess from the regional obstructive pulmonary emphysema associated with infections of the respiratory tract in infants and children. After partial contraction the cavities may re-expand without the recurrence of inflammatory changes in the adjacent lung and without re-accumulation of fluid in the cavities or signs of infection. If the size of the cavity were regarded as a criterion of pulmonary destruction, it would be erroneously decided that the pulmonary suppuration was progressing and surgical measures were indicated. A similar situation is occasionally encountered in the aerobic pulmonary infections in adults.

PARASITIC CYSTS

Parasitic cysts of the lung are uncommon in North America.[11] Echinococcic or hydatid cysts are the most important type of pulmonary cyst. Hydatid disease is most common in the Mediterranian region, Australia, New Zealand and parts of South America.[4] Of the small number of cases of echinococcic cysts of the lung which have been reported from the North American continent, in all except a few instances the disease was probably acquired while living in another part of the world. Hydatid cysts usually involve the liver, but the lungs are the second most frequent site of involvement. Hydatid cysts of the lung may be primary or secondary; the primary cyst is the more common. The right lung is involved more frequently than the left. The base of the right lung is a frequent site of hyatid cysts due to extension of the disease from the liver through the diaphragm.

An intrapulmonary echinococcic cyst may cause no symptoms for a long period of time unless rupture into the bronchus or the pleural cavity has occurred. In some cases cough is an annoying symptom. Hemoptysis is common. Pain may be present and dyspnea may be produced by a large cyst. The intrapulmonary hydatid appears on the roentgenograms as a round or oval area of increased density. The borders of the shadow are less sharply defined than in the case of solid tumors. The shadows may be single or multiple. There may be evidence of associated pleural involvement. As the pulmonary hydatid enlarges, it may rupture either into a bronchus or the pleural cavity. If rupture into a bronchus has occurred, a fluid level may be present within the cyst. When an echinococcic cyst ruptures into the bronchial tree, salty-tasting, clear fluid may rush into the mouth, and portions of cyst wall may be coughed up. Godfrey[6] states that deeply placed peribronchial cysts frequently undergo spontaneous cure if they rupture into a bronchus. After a hydatid cyst has ruptured into a bronchus, the cyst may become secondarily infected and the sputum foul. Then the patient presents the picture of pulmonary suppuration. Echinococcic cysts may be differentiated from nonparasitic fluid containing cysts, intrapulmonary tumors or abscesses, localized empyema and mediastinal cysts. The precipitin test, the intradermal test, and the complement fixation test combined with the demonstration of an eosinophilia, which is present in half the cases, may aid considerably in the diagnosis. Aspiration of the hydatid cyst is contraindicated because of the danger of spilling the contents of the cyst into the pleura and because of the possibility of anaphylaxis. If the cyst has ruptured into a bronchus, hooklets may be demonstrated in the expectorated material.

Most authors recommend surgical therapy for the large echinococcic cysts. Early surgical treatment is also indicated in small, subpleural echinococcic cysts because there is considerable risk of spontaneous rupture into the pleural cavity and the chance of spontaneous cure by rupture into a bronchus is poor. Surgical intervention is not usually recommended for the small deeply situated cyst near the pulmonary hilum because of the frequency of spontaneous cure in this group following rupture into a bronchus. In the removal of an echinococcic cyst it is important to avoid contamination of the pleural space. Some surgeons recommend complete extirpation of the cyst with closure of the chest without drainage. A one-stage operation may be performed with suture of the pleural layers if adhesions are not present. In the two-stage operation the first stage is given over to the creation of adhesions between the lung and the pleura, and the cyst is removed at the second operation.

CONCLUSIONS

The indiscriminate grouping of a variety of pulmonary lesions as pulmonary cysts leads to confusion. The various lesions should be classified according to etiology and pathology as far as this is possible.

Many acquired lesions have been incorrectly assumed to be congenital; radiographic differentiation of congenital and acquired cysts is often not possible.

Unless the mechanism of development and the pathological characteristics of a pulmonary cavity are considered, the correct therapy may not be employed.

Cavities produced by pulmonary destruction must be differentiated from cavities produced chiefly by hyperinflation. The treatment of epithelized and nonepithelized cavities frequently differ.

Surgical therapy plays an important rôle in the management of certain types of pulmonary cysts.

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A really simple goiter, . . . without either toxicity or degeneration, is really only a deformity caused by the distention of follicles with colloid, a physiologic disturbance capable of being influenced by therapeutic measures.

PRINCIPLES IN THE MANAGEMENT OF PULMONARY ABSCESS*

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EXCLUDING neoplasm, pulmonary abscess is one of the most serious diseases of the lung. The mortality in reported series ranges from 30 to 50 per cent. Sweet[1] reported a mortality rate of 34 per cent in 124 cases; Cutler and Gross[2] reported 38 per cent in eighty-five cases; Brunn[3] reported 60 per cent in 205 cases. Many other patients who did not actually die in the hospital were left as chronic pulmonary invalids due to irreparable damage to the lung by the infectious process. It is rare to find a reported cure rate of 50 per cent or over. In the past few years, Neuhof and associates,[4,5,6] and Overholt and Rumel[7] have shown markedly improved results in acute cases treated by prompt surgical drainage. Neuhof[6] and his group had four deaths in 104 acute abscesses, while Overholt and Rumel[7] reported two deaths in thirty-five "simple" (mostly acute) abscesses. Even more important was a cure rate of 94 per cent in Overholt and Rumel's series.

It is the purpose of this paper to add evidence to that contained in the recent reports, to indicate a broadening of the indications for surgical treatment, and to support the view that pulmonary abscess should be considered primarily a surgical disease from its onset. Conclusions are based upon twenty-five consecutive cases treated by the author with but one operative death.

DEFINITION

Pulmonary abscesses due to the tubercle bacillus or secondary to neoplasms are not included in this study. Likewise, multiple lesions on a definitely bronchiectatic basis or as a part of a generalized pyemia are excluded. Certain of the rare conditions such as infections due to Friedlander's bacillus or to fungi are not within the scope of this discussion. It does include, however, all other types and no effort has been made to consider separately various classifications such as acute or chronic, simple or complicated, putrid or aputrid, localized or diffuse, single or multilocular, or pulmonary gangrene. The underlying pathological process is the same in each instance; and although the manifestations may differ, the principle of early adequate drainage has been followed in all. However, the fulminating diffuse lesions or the frankly gangrenous processes will not yield as good results as are obtained in the treatment of early, acute, single abscesses.

BACTERIOLOGY

The bacterial flora of pulmonary abscess is variable. Usually a mixture of staphylococci and streptococci is found with frequent other associates. Both aerobic and anaerobic organisms are present in most instances. Specific therapy either with neoarsphenamine or one of the sulfonamide drugs has been disappointing, and bacteriology for the present has been relegated to a place of minor importance. Details of treatment may have to be varied according to the etiological organism but the principles of treatment are the same for all types.

It appears that most of the destructive and necrotizing organisms are either strict or facultative anaerobes. Reports on the bacteriology, unless including careful anaerobic cultures, are not significant. Many abscesses will be found to contain sterile pus if only aerobic cultures are taken. Although some of the organisms are very

virulent under certain conditions, many are easily destroyed by an unfavorable environment. Studies of these organisms

lectomy or tooth extraction. Some abscesses follow pneumonia, especially if the pneumonic process is due to a staphylococcus.
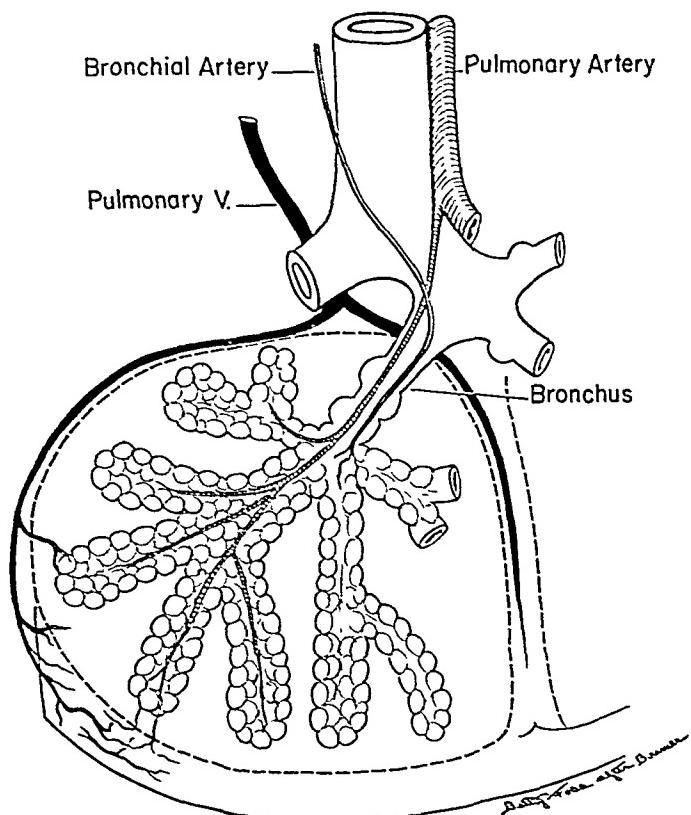
FIG. 1. A diagramatic drawing illustrating the close proximity of the pulmonary and bronchial arteries to the corresponding bronchus.

must take such factors into account. It is our practice to aspirate secretions from the abscess into a test tube at operation. This·material is then transferred immediately to a thermos bottle and kept at body temperature until it reaches the laboratory and is plated on various media. Such cultures most always show a mixture of organisms with staphylococci and streptococci predominating. Vincent's organisms may be recovered from the gums of a patient with a lung abscess, but they are not frequently encountered in the abscess cavity itself.

PATHOLOGY

We subscribe to the belief that aspiration of infected material into a bronchus is the primary cause of most pulmonary abscesses.[8,9,10] This material may be inhaled from infected gums during sleep or at operation. It may be detritus at the time of tonsil-

Although other factors, such as a septic embolus, are occasionally responsible, it seems likely that all but the exceptional case are due to aspiration.

When the bronchial lumen to a segment of lung becomes occluded, the portion of lung beyond becomes atelectatic and a perfect environment for anaerobic organisms is established. The spread of infection to the peribronchial structures impairs the blood supply to the segment beyond and hence in the course of a few days the area may become necrotic and symptoms of lung abscess appear. The close relationship of the bronchus and blood supply to a pulmonary lobule is shown diagrammatically in Figure 1. Peribronchial infection need not be extensive to include the accompanying branch of the pulmonary artery.

Mathes, Holman and Reichert[11] found that bronchial occlusion in the dog was universally fatal unless the foreign body

(sponge) was removed. Likewise pulmonary embolus although well tolerated in the absence of infection was always followed by abscess formation in the presence of infection. A septic bronchial obstruction by extension of the infection to the accompanying pulmonary artery resulting in thrombus formation can provide this serious combination.

Infection in a pulmonary segment calls forth the usual protective inflammatory wall. This protective wall is seen on inspecting the interior of the abscess cavity at operation and is further evidenced by the almost universal finding of pleural symphysis over the peripheral portion of the abscess. When this protective process is not sufficient, extension of the necrotizing pulmonary process to the surface of the lobe results in empyema.

Pulmonary abscess is a segmental lesion as shown by Glass.[12] The causative factor is located centrally and is the source of the diminished blood supply to the peripheral portion of the segment. Pulmonary arteries are end arteries, thus the periphery of a lobule has the poorest blood supply. This region, therefore, is the first to undergo dissolution and the abscess first becomes manifest in this area. The periphery of the lobule forms the periphery of the lobe, thus abscesses due to bronchial occlusion must be in contact with either the chest wall, interlobar fissure, diaphragm or mediastinum. Abscesses which have been referred to as "central" are those not facing the lateral chest wall, or are so located as to project "centrally" on the posteroanterior roentgenogram.

BASIS FOR EARLY SURGICAL DRAINAGE

A certain percentage of lung abscesses will regress spontaneously and many of these may give no further symptoms after a period of medical management. The exact number that will do so is undeterminable but it is probably in the vicinity of 20 to 35 per cent. Medical management includes a good hygienic régime with postural drainage, medicaments, broncho-

scopic aspiration and pneumothorax. The latter, however, has been almost abandoned due to the high incidence of serious or even fatal complications. Reported series include King and Lord's report;[13] 40 per cent of the patients were cured and the mortality was 35 per cent among those treated medically. Rosenblatt[14] reports 7 per cent cured and 47 per cent dead. Jackson and Judd[8] report 42 per cent cured and 29 per cent dead by medical measures including bronchoscopy. However, in the series of Jackson and Judd there were thirty-seven other patients who were referred for surgical treatment, eighteen or 48 per cent of whom died, making a true mortality rate of 36 per cent for the whole series.

When medical management should cease in a given case and surgical treatment be instituted is a difficult question to decide. Most authors favor a period of six weeks to three months before considering surgical drainage. The results of surgery in such a group are likely to be poor, as those patients have suffered the effects of a long septic illness. Cutler and Gross[2] reported a mortality of 38 per cent in their group of eighty-five surgical cases, and Allen and Blackman[15] reported a mortality of 30 per cent in ninety-four cases. These figures based as they are on a group of poor risk patients after protracted medical management do not give a true picture of the possible surgical results. Assuming that of one hundred cases of lung abscess, thirty will recover spontaneously and 60 per cent of the remaining seventy will get well following surgery, it still leaves a 28 per cent mortality for the group as a whole. No one can predict which case will heal spontaneously or when a given case will become complicated. If surgery can cure more than 72 per cent of the group as a whole by operating upon all patients early in the disease, it would be better to operate upon all as in the end more patients would be living and well.

The same line of reasoning applies to the time at which operation should be carried out. If one cannot foretell with

certainty the stage at which complications will develop, all patients should be operated upon before any enter the complicated state. Rives, Major and Romano[16] in a study of one hundred fatal cases reported that 75 per cent of that group were frankly hopeless within one month of the time of onset. Sweet[1] reported four deaths out of eleven patients operated upon who had entered the hospital within four weeks of onset. He further states that "of 14 cases in which death occurred without operation, 10 died in less than 2 months after the onset of the disease." Jackson and Judd[8] found that eleven of twenty-five deaths occurring on "conservative" therapy were within two months of onset.

The principles of drainage of pulmonary abscess are essentially those which apply to an abscess in any other location. These are thorough and adequate drainage of the process at the earliest time and with as little disturbance of surrounding normal structures as possible. The small and inconstant lumen of an inflamed bronchus does not provide adequate drainage for a pulmonary abscess. A small opening of a comparative size would be considered wholly inadequate for an abscess located elsewhere. The frequent finding of a large amount of thick inspissated material within the abscess at the time of operation is further proof of the inadequacy of bronchial drainage. How can open drainage be provided with safety? It is necessary to take advantage of the superficial location of the lesion and the adhesions formed by the process. This can be done if there is accurate roentgenological localization.

ROENTGENOLOGICAL LOCALIZATION

Accurate preoperative roentgenographic localization is vitally important. Pleural symphysis is most secure and extensive over that portion of the abscess that is nearest the periphery. This site must be determined roentgenologically.

Preliminary fluoroscopic study will aid in determining the most advantageous position for taking the roentgenographic plates. Postero-anterior, lateral and anterior oblique views will usually be sufficient. It may be necessary to supplement these conventional views by overexposed or Bucky films, or projections of varying obliquity.

After the location of the abscess has been determined, its exact relationship to the chest wall should be checked by a repeated series of films after placing an appropriate radio-opaque marker. In placing this marker allowance for the shift of the chest wall structures must be made. The marker should be placed with the patient in the same position he will assume upon the operating table. Neuhof's practice of injecting a mixture composed of 2 to 3 m. of lipiodal and a dye into the intercostal muscles is helpful. The lipiodal will be seen on the films and the dye provides a visible landmark at operation. We have found that lamp black is more suitable than some of the dyes in that it remains visible in the tissues for a longer time.

ONE-STAGE OPERATION PREFERABLE

The possibility of contamination of the pleural space or a dessicating infection of chest wall structures are advanced as reasons for employing a two-stage procedure. It has been found by Neuhof,[4,5] Overholt and Rumel,[7] and confirmed by our own observations that if the abscess faces the thoracic cage, pleural symphysis will be found if the lesion is properly localized. The area of adherence may not be large but will be sufficient for safe drainage. It is interesting to note that in the report of Overholt and Rumel[7] empyema occurred as a postoperative complication four times as often after the two-stage drainage as after a one-stage procedure. By sealing off the fascial planes as described below, the fear of a dissecting cellulitus is more theoretical than practical. By obviating the former objections to the one-stage procedure this method becomes applicable to all abscesses except those facing an interlobar fissure, the diaphragm or medi-

astinum when chest wall adhesions may not be present.

The lapse of time between stages of a two-stage procedure may be hazardous. Even shortening the usual interval to only one or two days does not remove the risk. Occasionally, the first stage operation is followed by an exacerbation of the process or an extensive spread, thus converting a simple lesion to a complicated problem.

ANESTHESIA

It is our practice to employ procaine hydrochloride paravertebral block plus local infiltration.

Caution must be exercised to prevent spill-over of purulent material to other parts of the same lung or to the contralateral lung during operation. It is usually necessary to have the patient lie with the affected lung uppermost thus favoring "crossfire" spread. Such a complication can be minimized by use of a rather steep Trendelenburg position and close observation by the anesthetist, who should encourage the patient to cough and raise any material that may drain into the tracheobronchial tree. The use of positive pressure oxygen administered by means of a properly fitted face mask provides a further safeguard. This is begun as soon as the chest wall drainage path has been prepared. Maintenance of positive intrabronchial pressure causes air to flow from the interior of the tracheobronchial tree toward the exterior through the bronchial fistula communicating with the drainage tract. This blows any discharge from the abscess outward rather than allowing it to drain internally. Maintenance of the positive intrabronchial pressure furthermore tends to keep the periphery of the lung and the chest wall in apposition and lessens the likelihood of tearing friable pleural adhesions. The positive pressure is maintained until the abscess is drained, packed, the dressing applied, and the patient placed upon his operated side.

OPERATIVE TECHNIC

The patient is placed on the table so that the site for the incision is conveniently located. Marked Trendelenburg position is used to favor drainage of bronchial secretions and to minimize the possibility of cerebral air embolism. The site of incision depends entirely on the location of the most peripheral portion of the abscess. It is placed so as to expose the rib directly over the center of the lesion. A five-inch skin incision is usually sufficient. If the operative field is in the axilla, a Y-shaped incision may be used to advantage as this prevents too rapid closure of the chest wall structures. The skin and subcutaneous tissues and muscles are divided down to the underlying ribs. A four-inch segment of the rib is subperiosteally resected, the ends sealed with bone wax and the corresponding intercostal bundle is ligated at either end. The intercostal nerve accompanying the rib above is crushed. With a continuous suture of fine chromic catgut, the subcutaneous fascia and intercostal structures are approximated so as to seal off all fascial planes. (Fig. 2.) At this point the anesthetist begins the administration of oxygen under moderate positive pressure so as to keep the lung and chest wall in apposition. An incision is made through the periosteal bed until the lung is encountered. This establishes by actual inspection the presence or absence of pleural adhesions. If they are found, one may proceed with drainage. If not, localization has probably been inaccurate or the lesion does not point on the chest wall. It is wise then to place a piece of gauze with a metal marker attached, such as a Michel skin clip, in the incision, pack the wound and re-examine the patient roentgenographically to check the localization. If adhesions are present, a 17 or 18 gauge needle attached to a syringe is introduced 1 to 2 cm. into the underlying lung. If the localization is correct, pus or foul-smelling air should be obtained immediately. The needle is left in place as a guide and with the actual cautery a

moderate-sized opening is made in the wall of the abscess. (Fig. 3.) Large openings are to be avoided as they may extend beyond
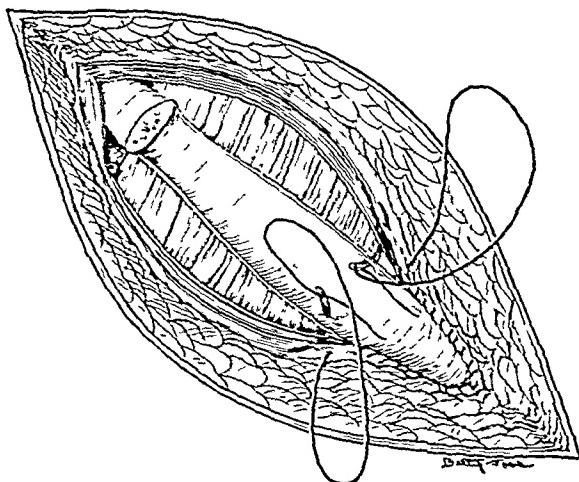
FIG. 2. Drawing to show suturing of subcutaneous fascia to the periosteal bed. A segment of rib has been subperiosteally resected. The accompanying intercostal vein, artery and nerve have been ligated and divided.
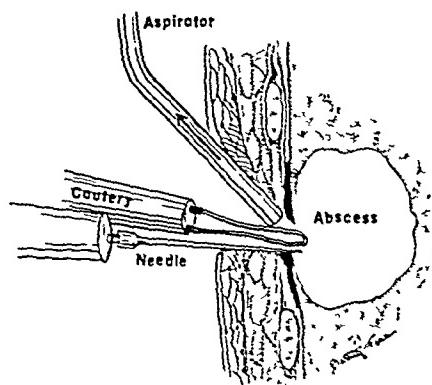
FIG. 3. Opening of the abscess with the cautery after aspiration with a needle. Note the sucker which removes smoke from the operative field and prevents spillage of the contents of the cavity.

the zone of pleural adhesions. A suction tube removes smoke from the operative field, and prevents gross contamination of the wound by the contents of the cavity. The cavity is evacuated with the sucker and material obtained for culture. With as little manipulation as possible, the cavity is cleaned out and packed lightly with dry gauze. It is our practice to place 4 to 5 Gm. of powdered sulfathiazole into the abscess, and another 1 to 2 Gm. are sprinkled into the wound to discourage bacterial growth.

A piece of rubber dam with an opening to allow drainage is sewn to the edge of the drainage tract to make subsequent dress-
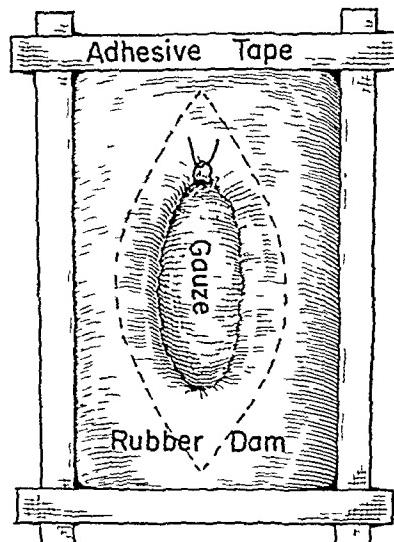
FIG. 4. Drawing illustrating the use of rubber dam to prevent adherence of the gauze pack to the wound. The rubber dam is sewn down to the intercostal structures.
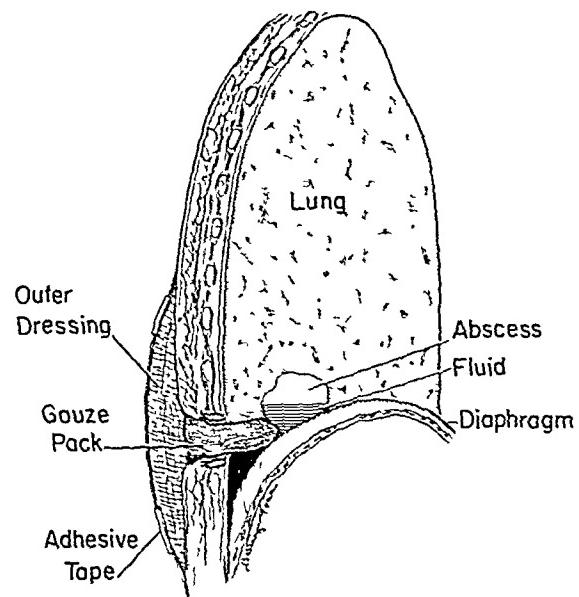
FIG. 5. Illustrating the method of preparing a safe drainage tract for an abscess pointing on the diaphragm. A segment of rib has been removed. The gauze pack inserted to the border of the abscess will cause adhesions to form, thus sealing off the pleural space.

ings easy to change. (Fig. 4.) This prevents the gauze pack from becoming adherent to the skin and subcutaneous structures. A dressing is applied and the patient turned upon the operated side, and then and only

then is the positive pressure oxygen discontinued.

TECHNIC FOR ABSCESSES NOT FACING THE THORACIC WALL

Abscesses facing the interlobar fissure, diaphragm or mediastinum may demand a two-stage drainage in order to provide a safe drainage tract through a nonadherent pleural space. The site of drainage is selected that is nearest to the underlying abscess. The operation is carried out as in the one-stage procedure to and including the incision of the pleura. The costal pleura may be found nonadherent. The space between the chest wall and the abscess is packed with a strip of gauze as illustrated in Figure 5. Two to five days later, the pack is removed and the abscess opened and treated as in the one-stage operation.

MULTIPLE ABSCESSES

Many abscesses become multiloculated. If the loculations all originated as direct extensions from the original process, they will be found to communicate with the main cavity and thus all may be drained at one time. In some cases adequate drainage may not be obtained and subsequent cauterization becomes necessary. This usually can be carried out through the original approach. Pulmonary suppuration following staphylococcic pneumonia may present a complicated problem. One or more segments of the lobe usually contain multiple abscesses filled with thick, almost gelatinous pus which drain poorly through the bronchi. The entire segment may have to be destroyed by repeated cauterizations. This may necessitate an approach from more than one avenue.

Distinct multiple abscesses in separate parts of the same lobe or in different lobes will be found in some cases when first observed. (See Cases 11, 12, 16, 19 and 21.) These must be drained through separate approaches at separate operations, attacking the largest or most acute process first.

In special instances in which the process is of long duration with marked pulmonary fibrosis and accompanied by extensive bronchiestasis, resection of the involved lobe or lung may be indicated. In general, the results of lung resection for acute abscesses are encouraging but still entail a quite high mortality.[1,7] Preliminary drainage to enable the patient to improve may be a necessary first step.[1]

POSTOPERATIVE MANAGEMENT

Care of the operative site is most important. In general, the original dressing is left in place from four to seven days. Plain dry gauze seems to be the best packing material. If the secretions are malodorous, the responsible anaerobic organisms can be quickly brought under control by packing the cavity daily for a few days with gauze soaked in zinc peroxide. The frequency of change of the pack is determined by the amount and character of the discharge. Dusting the inside of the abscess with sulfathiazole has been found effective in combatting bacterial growth. As the healing process progresses, the walls of the cavity close in and when it becomes too small to pack easily, a soft rubber tube is inserted and fastened securely in place with adhesive strips to a safety pin which is passed through the end of the tube. The caliber of the tube can be diminished as the sinus decreases in diameter. Withdrawal of the tube is not to be hurried. It may take several months for the healing process to be completed. The tube should not be less than 1 or 2 cm. shorter than the sinus. It must be left in place until the bronchial fistula has closed. This will take place spontaneously in all but a very few cases. After waiting several months, it may be necessary to resort to a muscle plastic closure of the bronchial fistula. This rarely has been found to be necessary in our cases. In no instance in which it has been used has it failed to produce permanent closure of the fistula with resultant solid chest wall healing.

AVOIDANCE OF COMPLICATIONS

Complications are usually due to an inaccurate approach to the lesion. This

may result in either pleural contamination or in complications due to approaching the abscess through a portion of normal lung tissue, or both. Finding extensive pleural adhesions may lead to the false belief that one has accurately localized the abscess because adhesions may be present which bear no relation to the abscess. If one cannot obtain pus or foul air on aspiration, extreme caution should be exercised, and in most instances further x-ray studies are in order. Establishing a drainage tract through normal lung parenchyma opens fresh tissue to infection and increases the danger of air embolus. Our findings bear out Neuhof's[4] statement that the most superficial portion of the cavity wall is avascular. The abscess may be opened in this area without danger of air embolus.

RESULTS

The results of surgical treatment of lung abscess based upon a consecutive series of twenty-five* patients treated by the author are summarized in Table 1. There were twenty-four recoveries with one death (4.0 per cent). All patients except the one fatal case showed marked improvement as soon as adequate external drainage was provided. Postoperative empyema did not occur in any case in which one-stage drainage was used. A dissecting infection of the chest wall did not develop in any case. Cerebral air embolism was not encountered.

Five patients (Cases 11, 12, 16, 19 and 21) had two or more separate and distinct abscesses requiring separate operations. In four instances, (Cases 11, 12, 16 and 21) the lesions were in different lobes. The one fatal case had multiple abscesses in all five lobes.

The time from onset of symptoms to drainage varied from one to sixty weeks. In ten cases, the duration of symptoms was six weeks or less. The one fatal case (Case 21) was of five weeks' duration. It is quite likely he would have survived had drainage been provided before a massive spread

* The first twenty cases in this series were included in a previous report.

took place. This patient illustrates the fallacy of waiting any specified time before instituting surgical treatment. One-fourth of the abscesses (six patients) followed tonsillectomy. This is a high percentage, but was assigned as the cause only when the evidence was irrefutable. Excluding the fatal case, one patient who was transferred to a psychopathic hospital, and two who are still under observation, the average period of hospitalization following drainage was forty-five days. This is in marked contrast to the duration of hospitalization on a medical or a combined medical and surgical régime. Brunn[3] reported the average duration of hospitalization in his collected series of patients under combined medical and surgical management as 154 days.

Of the abscesses facing the thoracic cage, adhesions were found in all instances when localization was correct. Note in Table 1 that the two-stage operation was supplanted by the single procedure in the more recent cases as greater attention was paid to accurate roentgenological localization. Likewise, the number of cauterizations was reduced and has approached the desired level of one per patient.

Four detailed case histories illustrating different types of abscesses encountered, including the one fatal case, are presented below.

CASE REPORTS

CASE 21. Mr. J. D., Jr., a forty year old male, married, insurance salesman, was admitted to the New England Deaconess Hospital on September 26, 1940, with a chief complaint of cough, expectoration, dyspnea, palpitation and a loss of twenty-two pounds in weight.

Six weeks before admission the patient had been operated upon for chronic appendicitis under ether anesthesia. The postoperative convalescence was uneventful. However, the patient failed to regain strength. He was discharged on the twelfth postoperative day. Two days later he began to cough and raise large amounts of greenish, foul-smelling sputum, and noticed a dull ache in the left side of the chest. Blood in the sputum was seen on three occa-

TABLE I
SUMMARY OF CASES

Series No.	Patient	Hosp. Adm. Date	Age	Sex	Duration Symptoms Preop in Weeks	Etiology	Cavity Present	Multilocular	Single Lobe	More than One Lobe	Plus interlobar Empyema	(pleura)	Abscess Plus General Empyema	Aerobic	Anaerobic	Type of Operation	No. of Cauterizations	P-O Empyema	Hosp. Days Drainage to Discharge	Op Death	Late Death	Comments and Present Status
1	C. K.	5-27-38	35	M	20	Postop. T and A	+	-	+	-	-	Chest wall	-	Staph Albus Hemoly	Staph Aureus	Exp. thoracotomy with subsequent drainage	2	+	52	-	-	Was well and working when last seen 3/39. Unable to follow since
2	O. H.	7-6-18	19	M	18	Unknown	+	+	+	-	+	Chest wall and fissure	-	No growth		One stage drainage	5	-	74	-	-	Working. Has bronchial fistula without drainage. Refuses to have it closed
3	A. B.	9-21-38	11	F	56	Postop. T and A	+	?	+	-	-	Chest wall	-	Staph Aureus, Hemoly	.	Two stage drainage	1	-	13	-	-	No symptoms. Attending school.
4	E. M.	10-6-38	13	F	36	Unknown	+	+	+	-	-	Chest wall	-	Hemoly Staph. Aureus	Unclass bacilli	Two stage drainage	2	-	56	-	-	Asymptomatic. Does own housework.
5	I. J.	11-12-38 / 2-25-39	12 / 21	M	12 / 9	Postop. T and A	+	?	+	-	-	fissure	-	Staph Aureus Hemoly	No growth	Two stage drainage / One stage drainage	1 / 2	+ / -	26 / 81	- / -	- / -	Following 1st operation had recurrence of abscess. Redrained. Empyema. Prolonged hospitalization. Working full time as truck driver. Is asymptomatic.
6	P. S.	11-21-38	51	M	21	Post convulsion	+	+	+	-	-	Chest wall	?	Spirochetes and fusiform, Staph. Aureus	Staph Aureus—Non Hemoly. Strept.	One stage drainage	1	-	28	-	-	No pulmonary symptoms when last seen 3/39. Mental symptoms continue.
7	T. P.	3-17-39	56	M	7	Oral sepsis	+	-	+	-	-	Chest wall	-	Spirochetes Staph Aureus	Staph. Aureus	One stage drainage	1	-	28	-	+	Died 11/7/39 of hypertensive cardiovascular disease. Had no post-op. pulmonary symptoms.
8	R. T.	5-12-39	50	F	5	Postpneum	+	-	+	-	+		+	Staph Aureus	Staph Aureus	Drain, empyema and abscess	o	+ Present preop.	34	-	-	Does own housework. Bronchoscopy and bronchography, 10/9/39 showed no pulmonary pathology.
9	T. C.	8-21-39	12	M	6	Postop. appendectomy	+	+	+	-	-	Chest wall	-	Vincent's organisms, Staph. Aureus Hemoly.	Staph. Aureus	One stage drainage	.	-	10	-	-	Working. No pulmonary symptoms.
10	E. M.	8-20-19	8	M	6	Postop. T and A	+	-	+	-	-	Chest wall	-	No growth	Staph. Aureus Hemoly.	One stage drainage	1	-	20	-	-	No symptoms. Attending school.

							First stage only of two stage drainage one stage drainage											Postop. T and A			

11	H. A.	9-12-30	19 F	18	Following 1st operation had recurrence of symptoms and abscess in lower lobe reappeared. Following 2nd drainage had uneventful convalescence. Now asymptomatic and working.	—	—	—	26	—	—	—	—	—	—	—	—	—	—	—
		2-16-40				—	—	—	21	—	1	Drain. interlobar empyema	No growth	Strep.	—	Chest wall	+	+	—	—	=	=
12	C. G.	10-18-39	38 M	36	Upper abscess disappeared following drainage of lower lobe abscess. Upper lobe process reappeared. Drained. Now asymptomatic.	—	—	—	55	—	1	One stage drainage	B. Coli	Diphtheroids	—	Chest wall	—	+	=	=	Unknown
		9-2-40				—	—	—	32	—	1	One stage drainage	B. Coli	Strep.	—	Chest wall	—	—	=	=	
13	T. C.	10-28-39	33 M	60	Symptoms recurred following first operation. Redrained. Now asymptomatic and working.	—	—	—	43	—	1	One stage drainage	B. Proteus	B. Proteus	—	Chest wall and fissure	+	—	=	=	+	Unknown
		1-21-40				—	1	—	60	—	1	One stage drainage	Non. Hem. Staph.	No growth	—	Chest wall and fissure	—	—	1	—	
14	E. B.	1-9-40	58 M	5	Had no pulmonary symptoms following operation. Died 5/40 of cerebral hemorrhage.	+	—	—	56	—	1	One stage drainage	Staph. Aureus	No growth	—	Chest wall	—	—	+	+	+	Oral sepsis plus accident with unconsciousness
15	C. W.	1-15-40	12 M	20	Asymptomatic. Working.	—	—	—	29	—	1	One stage drainage	Fusiform bacilli	B. Pyocyaneus	—	Chest wall	—	—	+	+	+	Dental extraction
16	W. G.	3-11-40	12 M	3	Developed Strep. bacteriemia. Cured by chemotherapy. Now in excellent health.	1	—	—	31	—	1	One stage drainage	....	....	—	Mediastinum	1	—	1	—		Unknown
						1	+ (2)	(2)			1	Two stage drainage	Hem. Staph. Aureus	Gram neg. rods.	—	Chest wall	1	+ (2)	1	+ (2)	
17	H. C.	5-23-40	17 M	20	Transferred to Psychopathic Hospital after 1st operation. Tube removed. Abscess recurred. Redrained. Still has fistula.	—	—	—	7	—	1	One stage drainage	....	....	—	Chest wall	—	—	+	+	+	Postconvulsive
		2-27-41							54	—	2	(Redrainage) One stage drainage	B. Coli	Diphtheroids, Staph.	—						
18	A. C.	7-20-40	52 M	3	No symptoms from abscess. Has advanced pneumococcniosis.	—	—	—	28	—	1	One stage drainage	B. Coli	B. Coli	—	Chest wall	—	—	+	+	+	Oral sepsis
19	G. D.	7-20-40	38 M	6	Diabetic. Bronchial fistula present. Working.	—	—	—	39	—	1	One stage drainage	....	....	—	Chest wall	—	—	+	—	Unknown
20	L. H.	8-28-40	28 M	12	Asymptomatic. Working.	—	—	—	21	—	1	One stage drainage	Diptheroids	B. Coli	—	Chest wall	—	—	+	—	Post. T and A
											1	One stage drainage	B. Coli Strep.	Diphtheroids, B. Coli	—						Postappendectomy
21	J. D. Jr.	9-26-40	10 M	5	Extensive multiple cavities in every lobe.	—	—	+	Died 10 days p.o.	—	1	One stage drainage	B. Coli Strep.	No growth	+	Chest wall	+	+	+	+	
22	L. C.	12-5-40	10 M	6	Asymptomatic. Working.	—	—	—	20	—	1	One stage drainage	B. Coli fusiform bacilli	Yeast organisms.	—	Chest wall	—	—	+	—	Unknown
23	V. G.	1-30-41	31 F	2	Asymptomatic.	—	—	—	25	—	1	One stage drainage	No growth	No growth	—	Chest wall	—	—	+	+	Postpneumonic
24	C. V.	5-12-41	33 F	43	Has bronchiectasis. Fistula still open.	—	—	—		—	1	One stage drainage	Diphtheroids	Diphtheroids	—	Interlobar fissure	—	—	+	+	Postteeth extraction
25	H. M.	5-5-41	51 F	1	Still has bronchial fistula.	—	—	—		—	1	One stage drainage	Strep. viridans, B. Coli	Staph. Aureus	—	Chest wall	—	—	+	+	Postop. cholecystectomy

* As of June 1, 1941.
† Case reported in detail.

sions. He consulted his physician who had a chest x-ray taken. (Fig. 6A.) The x-ray interpretation was tuberculosis. Approximately one

His past history revealed no pertinent information. The only previous illness was a gonorrheal infection at twenty years of age.
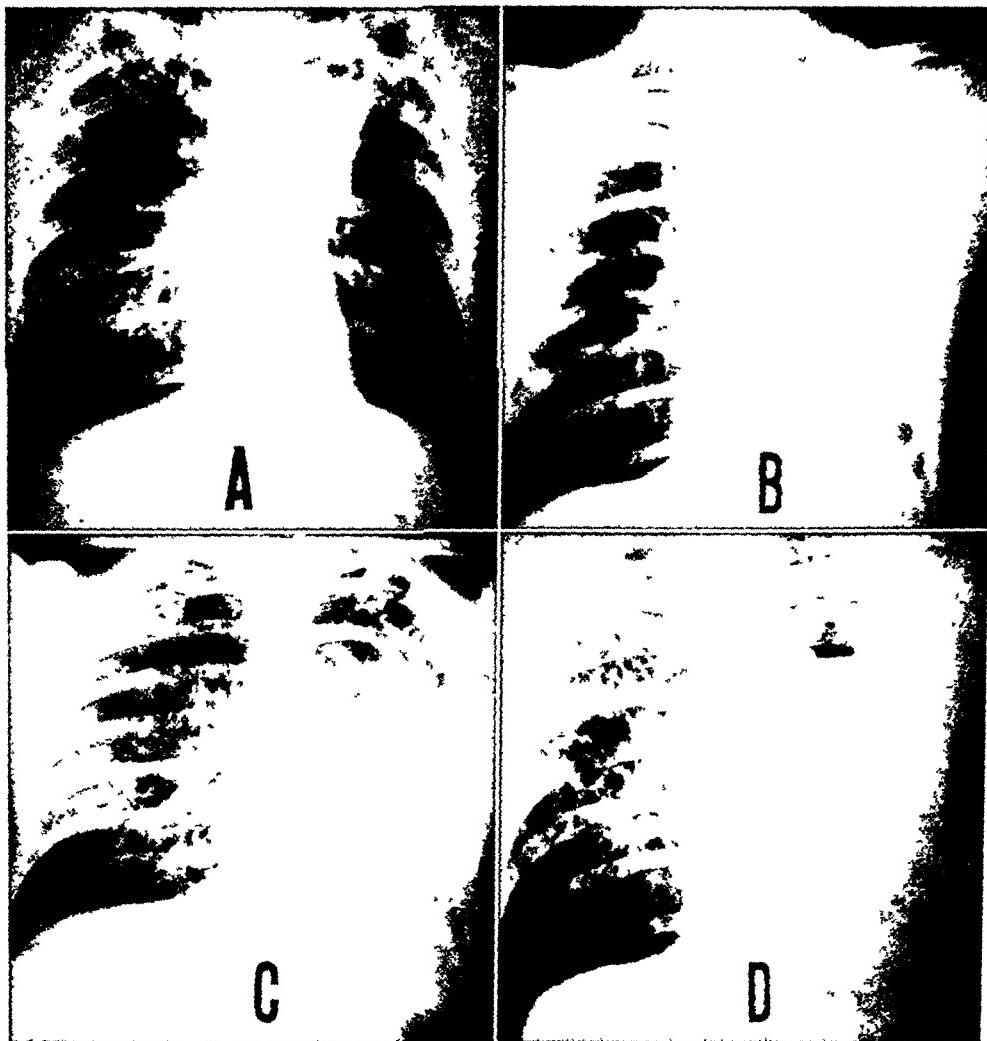
Fig. 6 Case 21. Postero-anterior x-rays of the chest showing rapid progress of an initially favorable lesion. A, August 29, 1940; B, September 6, 1940; C, September 25, 1940, D, September 27, 1940. Note the presence of an old tuberculous process in both apices. Due to this finding, a diagnosis of tuberculosis was made and valuable time was lost.

week later the patient entered a tuberculosis sanatorium. X-rays taken on admission there showed an extension of the lesion. (Fig. 6B.) Repeated sputum examinations for tubercle bacilli were negative. Bronchoscopic aspiration was carried out twice with slight temporary improvement. The course in the sanatorium was progressively downhill, the patient having a high sustained temperature, profuse prostration, copious expectoration and persistent pain in the chest. When seen in consultation, immediate surgical drainage was advised. This advice was not accepted until two weeks later.

There had been no known contact with tuberculosis. The patient had been married ten years. There were three children living and well.

Physical examination revealed a markedly dyspneic, emaciated, moderately cyanotic man, sitting up in bed in obvious respiratory distress. Significant abnormal findings were limited to the chest. There was dullness and diminished breath sounds over the lower two-thirds of the left chest posteriorly. Rales were heard over the entire left chest and a moderate number throughout the right chest. The heart was within normal limits and the sounds were of

good quality. The blood pressure was 88/50 mm. of mercury.

A urinalysis was essentially negative except for a very slight trace of albumin. The white blood count was 37,300, red blood count 4,180,000 per c.mm. The hemoglobin was 81 per cent. Differential: polymorphonuclears 77 per cent, lymphocytes 11 per cent, large mononuclears 8 per cent, eosinophiles 3 per cent, basophiles 1 per cent. There was moderate anisocytosis.

Roentgenographic examination (Fig. 6d) showed an extensive bilateral involvement with a large multilocular cavity of the left upper lobe. The lower two-thirds of the left chest was obliterated by a moderately dense homogeneous shadow. There was evidence of many smaller cavities throughout the upper two-thirds of the right lung.

Intensive sulfanilamide therapy was started. Although it was thought that the outlook was practically hopeless drainage of the large abscess in the left upper lobe was decided upon. The preoperative temperature was 102°F. and the pulse rate was 160 per minute. A one-stage cautery drainage was carried out on September 28, 1940. This was followed by two indirect blood transfusions.

His course following operation did not change greatly. His temperature remained quite steady at around 102°F. by rectum, and the pulse 130 to 140 beats per minute. Chemotherapy was maintained with a sulfanilamide blood level ranging from 8 to 10 mg. per cent. Fluids were administered parenterally to maintain an intake of 3,000 to 4,000 cc. per day. Blood transfusions of 500 cc. each were given on September 29, October 1, and October 4, 1940. In spite of the supportive therapy it was obvious that the patient was slowly failing but there was no dramatic change in his course until the morning of the tenth postoperative day when he became comotose, temperature rose to 104°F. by rectum, and the patient expired.

Postmortem examination revealed a healed bilateral apical tuberculous process. The lung abscess of the left upper lobe which had been drained was found to involve approximately one-half of the upper lobe. The remainder of the left lung was described as "involved by a massive destructive process." One 10 cm. abscess and many smaller abscesses were found in the right lung. A very small abscess was present around the appendiceal stump.

How well this case illustrates the rapid progress such a process may make! The issue was confused in this particular instance because of the presence of an old tuberculous process at the apices. The development of the lung abscess in the upper lobe made it seem all the more likely that it was tuberculous. This assumption accounted for part of the loss of time in the application of proper therapy. Only within the first ten days after onset of symptoms could this patient be classed as at all hopeful. By the time of admission to the sanatorium, the prognosis was very grave, again illustrative of the fallacy of temporizing with a lesion so potentially dangerous. In the light of other cases it seems quite probable that had the original abscess been drained when it was first detected, the fatal issue would have been averted.

Case 9. Mr. T. C., a forty-three year old, married, Italian clerk was admitted to the New England Deaconess Hospital on August 24, 1939, with a chief complaint of cough, expectoration, and pain in the right chest of four weeks' duration.

On August 16, 1939, the patient developed symptoms of acute appendicitis. At operation the following morning a ruptured appendix was found. This was removed and a drain inserted. A right inguinal hernia was repaired at the same time. The patient had a stormy time postoperatively and ten days after operation began to complain of pain in the left chest. A cough developed and the temperature became more elevated. It was thought at first that he had a pulmonary embolus. Soon the patient began to raise large amounts of foul-smelling material. A fecal fistula developed at the site of the appendectomy. Sulfapyridine was given without benefit. Roentgenological examination of the chest revealed a large lung abscess in the left lower lobe. Thoracic surgical consultation was requested and the patient was transferred the following day to the New England Deaconess Hospital.

Physical examination revealed a very ill man sitting upright in bed, breathing with effort, coughing frequently and raising foul sputum. Many rales could be heard throughout the posterior aspect of the left chest. Amphoric

breath sounds were audible over the seventh and eighth ribs posteriorly. A profusely draining sinus was found in the right lower quadrant

The patient was followed at weekly intervals. For some time it was thought that it would be necessary to do a plastic operation in order to

FIG. 7. Case 9. Postero-anterior x-rays of chest. A, August 24, 1939. Note large multilocular abscess with surrounding pneumonitis in left lower lobe. B, August 23, 1940. Lesion has now cleared completely, following surgical drainage, except for slight pulmonary fibrosis.

of the abdomen. A right inguinal herniorrhaphy scar was well healed. The remainder of the examination was not significant.

Urine examination was normal except for 14 to 18 white blood cells per high power field. The white blood count was 21,700; red blood count, 3,580,000 per c.mm. The hemoglobin was 50 per cent. Differential: polymorphonuclears 92 per cent, lymphocytes 3 per cent, eosinophiles 1 per cent, young polys 4 per cent. Moderate achromia of the red blood cells was noted.

X-ray examination of the chest (Fig. 7A) revealed a large multilocular abscess in the left lower lobe with surrounding pneumonitis.

The patient's condition was desperate, temperature $101°F.$, pulse rate 146 per minute. A blood transfusion of 500 cc. was given as soon as possible after admission, and later that day a one-stage cautery drainage of the lung abscess of the left lower lobe was carried out.

The patient's improvement following operation was dramatic. The temperature returned to normal by the end of the first week. The pulse rate gradually dropped to an average of 100 within the same time. The fecal fistula closed spontaneously. The patient was able to be out of bed thirty days after operation and was discharged seven days later. The large defect of the left lower lobe gradually filled in and shortly before discharge a drainage tube was inserted to keep the skin from closing over.

close the bronchial fistula. However, the fistula healed spontaneously and the tube was removed on January 2, 1940, three and one-half months after discharge from the hospital. Since that time he has been entirely without symptoms now one and one-half years. He has returned to full time work and is in excellent health. (Fig. 7B.)

The postoperative response of this patient presents a dramatic illustration of the marked improvement that may be experienced by an acutely ill, toxic patient as soon as the abscess is decompressed and the patient is freed of persistent coughing and raising. Although this particular case was complicated due to an extensive pulmonary process with surrounding pneumonitis, a fecal fistula, and marked debilitation by the long septic process, the period of hospitalization following operation was not excessive and an excellent result was obtained. Judging from the patient's preoperative course, further temporizing would have been fatal.

CASE 22. Mr. L. C., a thirty-nine year old, married, American, carpenter was admitted to the New England Deaconess Hospital December 3, 1940, with a chief complaint of cough and expectoration of six weeks' duration.

The patient stated that in March, 1939, he was in another hospital for eight days because of cough and the raising of profuse, foul-smell-

ously, a film on November 7, 1940, (Fig. 8A) was said to have been the first one to show any abnormality. The cough was quite distressing
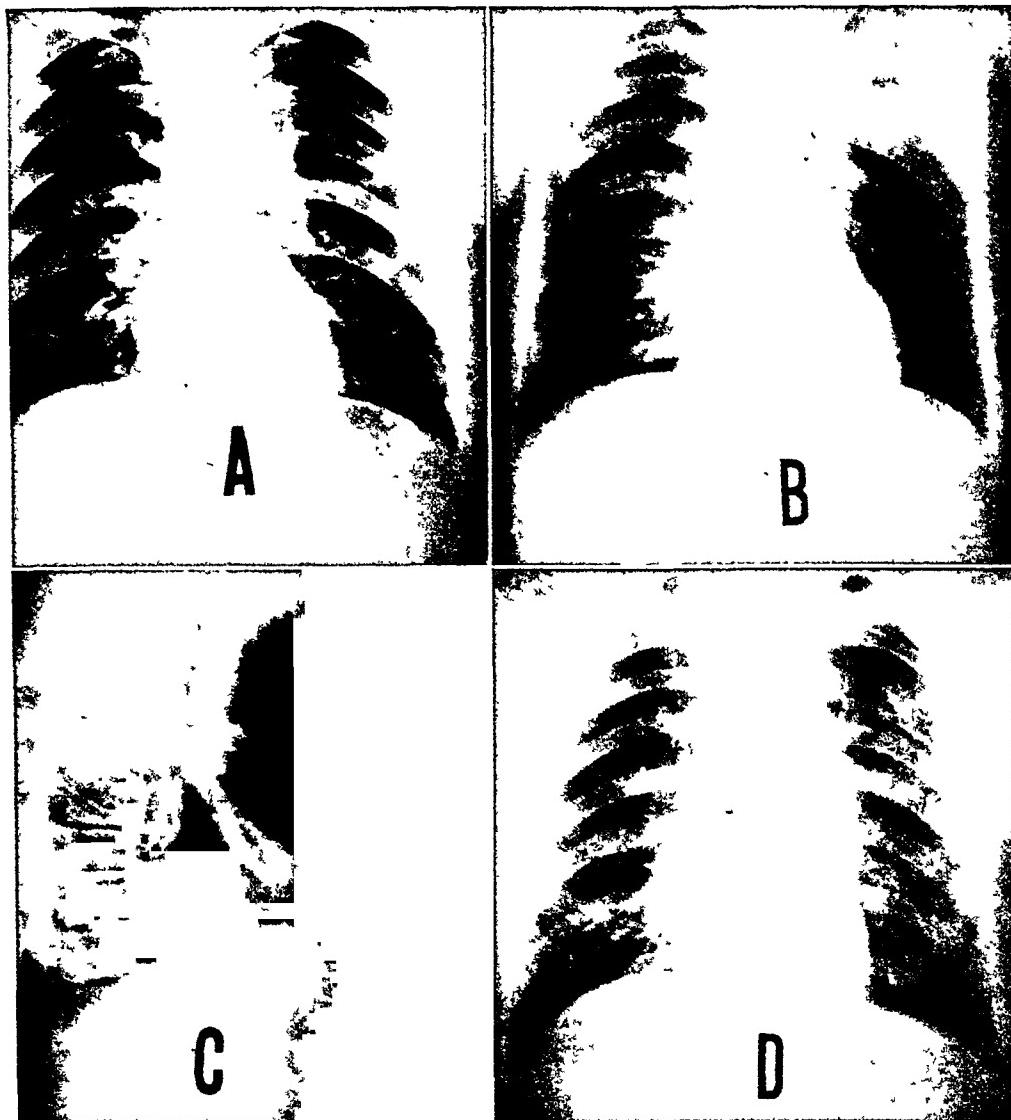
Fig. 8. Case 22. A, postero-anterior x-ray of chest. November 7, 1940, showing some infiltration of mediastinal segment of left upper lobe. The only complaint at that time was severe chest pain. B and C, postero-anterior and left lateral x-rays of chest approximately one month later, December 4, 1940. Patient now has a large lung abscess with marked cough and profuse expectoration. D, February 10, 1941. Lesion has now cleared completely following surgical drainage. Note lipiodal still in intercostal tissue above resected rib.

ing sputum. A diagnosis of lung abscess was said to have been made at that time on x-ray and clinical evidence. Upon discharge from the hospital he remained home for four months on a modified rest program. He then returned to work.

He felt well until the latter part of October, 1940, when he suddenly felt severe pain in the left side of the chest. After a two weeks' period at home he was transferred to the Essex County Tuberculosis Sanatorium for observation. Although numerous x-rays had been taken previ-

and he raised from two to three ounces of foul sputum per day. Surgical drainage was advised.

His past history was negative except for the episode recorded in the present illness. The family and marital histories were noncontributory.

Physical examination revealed the patient to be a well developed and well nourished man in no particular distress. There was moderate oral sepsis. The chest was symmetrical and expansion was full and equal. There was dullness to percussion over the upper part of the left

posterior chest. Harsh breath sounds were noted together with moist rales in this same area. The remainder of the chest showed nothing abnormal. The abdomen showed a well healed lower quadrant scar. Extremities were negative.

Laboratory examination revealed nothing abnormal in the urine. The white blood count was 28,200; red blood count, 4,650,000 per c. mm. and the hemoglobin was 87 per cent. Differential: polymorphonuclears 87 per cent, lymphocytes 5 per cent, large mononuclears 4 per cent, eosinophiles 4 per cent, basophiles 1 per cent.

Roentgenological examination of the chest (Fig. 8B and C) revealed an abscess in the lower part of the left upper lobe. A one-stage cautery drainage of the lung abscess was carried out December 4, 1940.

Postoperative convalescence was entirely uneventful, the temperature never going above 100°F. The pack was first changed four days after operation and every other day thereafter until the seventeenth postoperative day when a small rubber tube was inserted in place of the pack. The patient was allowed out of bed fifteen days after operation and was discharged on the twentieth postoperative day. Following discharge from the hospital, he was followed at weekly intervals and on February 1, 1941, the fistula was found to be closed and the tube was therefore removed. The chest wall healed promptly. When last seen on March 24, 1941, the patient had no complaints and an x-ray (Fig. 8D) showed complete clearing of the pulmonary process. He was given permission to resume normal activities.

One can speculate a great deal as to the length of time the lesion had been present. It is entirely possible that the recent abscess was the same lesion that was present in March, 1939. The re-activation of an abscess after apparent spontaneous healing has been a rather frequent occurrence. The rapid recovery made in this case again demonstrates that a smooth convalescence can be expected following drainage of an uncomplicated single abscess. Recurrence is rare following external drainage.

Case 23. Miss V. G., a thirty year old, single woman, was admitted to the New

England Deaconess Hospital on January 30, 1941, with a chief complaint of cough and temperature of two weeks' duration. Two weeks previously the patient had suddenly developed a high temperature, cough, and pain in the right chest. She was admitted to the Joseph H. Pratt Diagnostic Hospital where a diagnosis of right upper lobar pneumonia was made. A chest x-ray revealed a shadow in the right upper lobe consistent with lobar pneumonia. Intensive chemotherapy was given. Her temperature continued to range from 100 to 102°F., pulse rate 100 to 120. After thoracic surgical consultation, surgical drainage was advised and the patient was transferred to the New England Deaconess Hospital.

The patient had been a quite severe asthmatic since August, 1938. She was known to be sensitive to dust, lettuce and spinach. On intensive allergic therapy, however, she had been able to control her symptoms quite well. Two years previously a splenectomy had been performed for a ruptured spleen following an automobile accident. One year previously an ectopic tubal pregnancy was removed.

Physical examination revealed a thirty year old white woman sitting upright in bed in obvious respiratory distress. Respiratory wheezing was marked. Examination of the head and neck showed no abnormality except for very poor teeth. Percussion of the chest revealed dullness and diminished breath sounds over the upper part of the right chest posteriorly and in the right axilla. No rales were audible. Tactile and vocal fremitus were slightly increased. Wheezing and prolonged expiratory sonorous rales were heard throughout both chests. The heart appeared to be of normal size and without murmurs. The blood pressure was 120/70 mm. of mercury. Abdominal examination was negative except for left upper quadrant and low midline well healed scars. The remainder of the physical examination showed no abnormality. The temperature was 102°F.; pulse 140; respirations 30.

A urinalysis showed no marked abnormality except a slight trace of albumin and an occasional fine granular cast. The white blood count was 19,400; red blood count 4,600,000; hemoglobin 70 per cent. The differential count showed 63 per cent polymorphonuclears, 15 per cent bands, 7 per cent lymphocytes, 10 per cent monocytes, and 5 per cent eosinophiles. Serological examinations were negative. One blood culture was sterile.

Roentgenographic examination of the chest (Fig. 9A and B) revealed evidence of consolidation of the posterior portion of the right upper

occasions since that time. The wound is completely healed, and the last x-ray (Fig. 9C) shows complete clearing of the lesion.

Fig. 9. Case 23. A and B, postero-anterior and right lateral x-rays on January 29, 1941, showing involvement of lower part of right upper lobe. No evidence of cavitation. C, posterior-anterior x-ray April 18, 1941. Note complete clearing of process following surgical drainage.

lobe. The shadow was limited below by the interlobar fissure, but the upper borderline was indistinct. No definite cavity was visible. Although definite evidence of a lung abscess by x-ray was not present and the patient had practically no sputum, a diagnosis of lung abscess or interlobar empyema was made and operation advised.

On January 30, 1941, (the day of admission to the Deaconess Hospital), under local anesthesia, the posterior aspect of the right upper lobe was explored after resecting a portion of the fifth rib posteriorly. A multilocular abscess was entered, the cavities being filled with very thick, cheesy, yellowish pus. These abscesses were broken down and the space packed with gauze after application of sulfathiazole powder. Bacteriological examination of the material from the abscess revealed sterile cultures both aerobically and anaerobically, although Gram-positive cocci were found in clumps upon direct smear.

The patient's postoperative convalescence was satisfactory. Although the temperature rose to 103.5°F. the day of operation, it returned to normal quite rapidly and her general condition improved markedly. The patient was discharged from the hospital twenty-five days following drainage of the abscess.

She was followed at weekly intervals. A small tube which had been in place in the sinus tract before she left the hospital was withdrawn as the sinus tract closed in. The tube was removed on May 16, 1941. She has been seen on two

In this case a persistent area of infiltration by x-ray and continued signs of sepsis following an attack of pneumonia suggested pulmonary suppuration. Destruction of pulmonary parenchyma did not seem to be as extensive as that usually caused by anaerobic organisms. No area of excavation was present roentgenographically but at operation many small connecting pockets were found. It is better to expose such lesions surgically than to wait a prolonged period of time for definite evidence of cavitation by x-ray.

SUMMARY AND CONCLUSIONS

Early drainage of lung abscess has yielded a low mortality rate and a high cure rate in our experience. A series of twenty-five consecutive cases of pulmonary abscess treated by surgical drainage has been presented. There was one operative death.

Inhalation of material from the upper respiratory passages appeared to be the causative factor in the vast majority of cases. Symptoms had been present from one week to one year and two months before operation. Five patients had multiple abscesses, four of which were in more than one lobe.

In all cases surgical drainage was provided as soon after admission to our service

as diagnostic and localizing studies could be completed. Critically ill patients were treated as surgical emergencies.

Early surgical drainage protects the patient from the danger of bronchiogenic spread, multiple abscess formation and extensive irreparable pulmonary damage.

Pulmonary abscess should be considered a surgical disease from its onset. Every effort should be made to establish the diagnosis, localize the lesion, and provide external drainage without delay.

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RECOGNITION AND MANAGEMENT OF MEDIASTINITIS*

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ALTHOUGH chronic mediastinitis is a rare disease, acute mediastinitis is not nearly so infrequent as the profession once believed. Numerous reports in the past few years indicate the fairly common occurrence of acute infections of the cervical and thoracic mediastinum. When one considers the ease of access to the fascial planes for spontaneous infections of the mouth, nose and throat, cervical lymph-nodes, neoplasms of the pharynx and esophagus, and foreign bodies, it is fortunate that nature is so kind in building inflammatory barriers to prevent the downward extension of many of these infections.

An accurate concept of the practical anatomy of these fascial planes of the neck and thorax, as so vividly described by Furstenberg and Yglesias, demonstrates the continuity of the retrovisceral space as a compartment (Figs. 1 and 2) bounded behind by the prevertebral layer of cervical fascia, in front by the pharynx and esophagus and the lateral extension of the retro-esophageal fascia, which is a derivative of the pretracheal layer, and laterally by the carotid sheaths. It extends from the base of the skull to the diaphragm. This makes easy migration of infection from the retropharyngeal or retroesophageal locations into the posterior thoracic mediastinum, and it is remarkable that inflammatory barriers so frequently localize the infection to the cervical portion. Surrounding the viscera of the neck consisting of the pharynx and esophagus behind and trachea and thyroid in front, is a cylindrical sheath. This consists of the pretracheal layer which extends laterally to join the prevertebral layer at the carotid sheath and is continued posteriorly as the retropharyngeal or buccopharyngeal fascia above and the retro-esophageal fascia below, constituting the vasculovisceral fascia. This blends with the aorta as the arch crosses the trachea and encloses the descending limb. It continues downward to fuse with the pericardium at about the level of the bifurcation of the trachea at the sixth thoracic vertebra. Thus the other practical mediastinal space, the anterior or visceral space, extends from pharynx and larynx above to the bifurcation of the trachea below. The potential space immediately behind the sternum, included in anatomy textbooks as a part of the anterior mediastinum, is protected from the spread of cervical infections by the junction of the superficial layer of cervical fascia and its muscular investments, with the posterior surface of the manubrium sterni so that infections reach this space only when they originate from injury or infection of the anterior chest wall at the level of the first and second costal cartilages.

In the vasculovisceral fascial compartment lie many lymph-nodes and vessels, and it is into this space that nose, throat and ear infections frequently travel. On the other hand, perforations of the posterior pharyngeal or esophageal walls by foreign bodies usually involve the retrovisceral space and are more prone to extend deep into the thorax. One or both of these spaces may be implicated and the intimate relationship to the pleurae and pericardium leads to infection of these at times. Practically, then, there are two main spaces, the retrovisceral and the vasculovisceral, which may be infected and are continuous from neck to thorax with only theoretical, but no actual division between the cervical and thoracic portions. The concept that the mediastinum extends from the base of the skull to the diaphragm is a good one for practical purposes.

The extent to which infection of these spaces may spread is influenced by the

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amount of contamination, the virulence and the frequent multiplicity of organisms on the one hand, and the patient's resist-

Fig. 1. Diagram of coronal section at the level of the sixth cervical vertebra.

ance on the other. Thus a bad combination of perforation by foreign body through a small opening which does not allow spontaneous drainage, in a patient who has streptococci and spirochetes from oral sepsis and is suffering from more or less nutritional deficiency, may frequently lead to a rapidly spreading, diffuse, and necrotizing plegmon with such extreme absorption and toxemia as to result in death in one or two days. For such a patient, the prospects are poor, even with early drainage. Conversely, in patients with good resistance who have sustained perforations of the pharynx or esophagus with the demonstration of gas in the tissues, but in whom virulent bacteria were not present in large numbers, spontaneous and fairly rapid recovery has occurred on a few occasions. Between these two lie the great majority of cases resulting from either infections about the mouth, ears, or throat, or trauma to the pharynx and esophagus in which all combinations of the above two extremes occur. In many of these the infection is localized by inflammatory barriers and retained in the cervical region as a retropharyngeal abscess for a longer or shorter time. Even these, if neglected, tend to spread downward in many instances.

In a review of twenty-eight cases of cervical and thoracic infection of the mediastinum and ten cases classed as retropharyngeal abscess who were ad-

mitted to all services of Temple University Hospital over a period of the past five years, the source of infection is indicated in
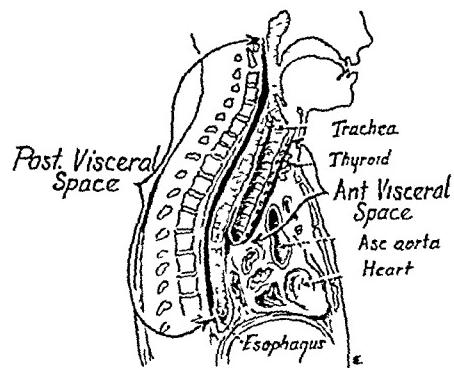
Fig. 2. Diagram of midsagittal section.

Table 1. The most common causes were perforation by foreign body and neoplasm and infections of the mouth and throat. Three of these latter followed extraction of teeth. One case occurred after otitis media and six cases after diagnostic instrumentation in the presence of ulcerative lesions, some of whom had symptoms suggestive of infection before examination. Two cases followed laryngectomy, and one thyroidectomy for extensive malignant disease. One patient sustained spontaneous perforation of the esophagus. Of the abscesses classed as retropharyngeal, eight followed upper respiratory infection, in most of which sore throat was stated, and two were secondary to otitis media.

TABLE 1
ORIGIN OF MEDIASTINITIS

	No.
Foreign body	9
Carcinoma esophagus	4
Perforation esophagus	1
Infections	6
Otitis media	1
Upper respiratory	2
Ludwig's angina after tooth extraction	3
Following endoscopy	4
Following operation	3
Laryngectomy	2
Thyroidectomy	1
Following passage of feeding tube	1
	28

The symptoms of the twenty-eight cases (excluding retropharyngeal abscess): Eleven showed dysphagia, eight dyspnea—

two of whom required tracheotomy—six had pain in the throat and seven pain in the chest, neck or back. In four there was vomiting, in three hemoptysis, and in two there was hoarseness. All but two had fever and in twenty it was moderate to high and frequently septic in character. Chills occurred in only three cases. Cyanosis was present in seven, swelling of the neck in thirteen and cervical tenderness in twelve. Abnormal chest signs were present in four cases.

The most constant evidence was demonstrated by x-ray. Due to obvious diagnosis or failure to consider the possibility, no x-ray was taken in four cases, but in the remainder all showed widening of the mediastinum or of the retrotracheal soft tissues depending upon location, and in fourteen there was gas present in the tissues.

Of the so-called "retropharyngeal" group, the symptoms consisted rather constantly of sore throat and difficulty in swallowing. A few references were made to labored or noisy breathing and to swelling of the neck. In the occasional case in which roentgen examination was done, thickening of the space between the vertebra and pharynx was revealed.

A review of the multiple cases in the literature shows that the etiology, symptoms and signs ascribed to the patients reported correspond to these we have outlined as to frequency of occurrence. The rare circumstance of mediastinitis secondary to osteomyelitis of the thoracic vertebra, suppurative lymphadenitis of peribronchial or peitracheal lymph-nodes from perforation or operation of neoplasms of the thoracic esophagus, and following pulmonary suppuration, empyema, or thoracic operations, is reported. Such origins usually result in abscesses localized to the thoracic portion of the mediastinum and may not be accessible from the cervical approach but require posterior mediastinotomy.

Acute mediastinitis is susceptible to accurate diagnosis if one will only consider

the possibility of its occurrence with infection or trauma of the mouth, nose, throat, ears or esophagus. Any patient may be considered a candidate for such diagnosis if any one or combination of the following is present: difficulty in breathing or swallowing, pain in the throat, tenderness or swelling in the neck. The only acute conditions which are likely to confuse one clinically are acute lymphadenitis, possibly tuberculous adenitis and the rare conditions causing increased superior vena caval pressure. The finding of emphysema in the cervical or thoracic mediastinum by clinical or x-ray means and the thickening of the visceral and retrovisceral spaces or widening of the mediastinum by x-ray associated with fever and leukocytosis, clinch the diagnosis. The main factors are the consideration of the condition in potential cases and the examination by x-ray of these soft tissues.

Results. In our group of ten cases in which drainage was not established surgically, four recovered and six died. Of the eighteen cases in which drainage was established surgically, twelve recovered and six died. These last six deaths were in patients with thoracic mediastinal involvement. The causes of death ascribed are tabulated. (Table II.) Thus the mortality was 33⅓ per cent of patients in whom surgical drainage was established and 60 per cent for those in whom it was not. (Table III.) Delay before admission, before recognition, and before surgery contributed significantly to the mortality of both groups since there was no intention to deny surgery to those patients. In only three of the twelve fatal cases did it appear that the virulence and extent were too great for surgical salvage, although it is questionable in two others even if early recognition and drainage had been accomplished. Although a few cases recover without operation, it is difficult if not impossible to select these in the early stages and it seems extremely dangerous to delay surgical drainage because of the occasional nonsurgical recovery. Delay not only increases the

parenchymatous damage from prolonged toxemia, but frequently leads to spread of an otherwise circumscribed infection. Particularly with the perforations of the pharynx and esophagus, constant recontamination occurs unless an adequate external vent is produced. The ten cases classed as retropharyngeal abscess were drained early through the posterior pharyngeal wall with rapid recovery.

TABLE II
CAUSES OF DEATH

Case	Days from Onset to Drainage	With Surgical Drainage
1	9	Carotid hemorrhage twelve days postoperative—ligation of carotid—hemiplegia—died in twenty-four hours
2	12	Delay—moribund at operation—edema—thin cloudy fluid
3	43	Died suddenly two days postoperatively—vascular accident
4	8	Inadequate drainage—temporary improvement—readmitted and died seven weeks later with healed wound and continued mediastinitis
5	8	Followed laryngectomy—extensive sloughing of wound
6	7	Followed thyroidectomy for advanced malignancy—extensive sloughing of wound and metastases

Without Surgical Drainage

1	17 hrs.	Too ill for multiple surgery—pericardial and bilateral pleural infection
2	4	Error in diagnosis—empyema only was drained
3	10	Moribund—error in diagnosis—only superficial extensions to neck and shoulder were drained
4	4	Unrecognized until postmortem examination; pericardial and bilateral pleural infection
5	8	Delay—moribund on admission—died during diagnosis in eighteen hours
6	30	Error in diagnosis

MANAGEMENT

When the diagnosis is established, cervical mediastinotomy should be instituted as an emergency procedure in every case with the exception of those rare infections which begin and remain below the fourth rib posteriorly. With such rare exceptions, posterior mediastinotomy should be done by resecting portions of two or three ribs and transverse processes at the appropriate level and retracting the pleura laterally and anteriorly until the mediastinal collection is entered. Soft rubber tubes, rubber dam or gauze are inserted to maintain the opening, and irrigations with oxidizing solutions are utilized until the drains can be gradually shortened and withdrawn. No posterior mediastinotomies were employed in this group, although indicated in Case XXIII.

TABLE III
197 CASES FROM THE LITERATURE

	Operated		Nonoperative	
	Recovered	Died	Recovered	Died
Pearse 99 collected 11 personal	44	24	6	36
Phillips	17	3		
Neuhof	25	—	9	25
	86	34 (30.5 per cent)	15	61 (80 per cent)

Cervical mediastinotomy should be instituted on the side of the neck which is indicated by clinical or radiological localization, or upon the right side if the infection is bilateral or only posterior. There is less likelihood of entering the pleura on this side than on the left. An oblique or transverse incision is made along the anterior border of the sternomastoid muscle through the superficial layer of the deep cervical fascia. The sternomastoid and carotid sheath are retracted laterally and the thyroid retracted medially which usually entails division between ligatures of the lateral vein and at times the inferior thyroid artery. If the abscess is anterior, it will be found more medial under the pretracheal fascia and if posterior, directly backward through the dense union of the pretracheal and retroesophageal fascial

planes with the carotid sheath. If palpation reveals a large space extending to the opposite side, some surgeons advocate repeating this procedure on the opposite side, although usually a unilateral approach allows adequate drainage.

If foreign body or instrumental laceration is suspected, search should be made for it. Foreign bodies can frequently be removed by esophagotomy alone or combined with esophagoscopy. Lacerations or surgical wounds have a marked tendency to reopen after suture unless fine steel wire is used. If adequate drainage is established, such openings heal spontaneously. With the finger, one must explore cephalically and caudally to determine the extent of the abscess and place two small rubber tubes at the extremities in each direction. Two tubes give better drainage than one, both through the lumens and between the pair, and allow for irrigation of deep spaces without production of dangerous positive pressure. Constant irrigation by drip with oxidizing solution such as Dakin's or azochloramid, offer the best chance for rapid dilution and mechanical removal of infectious products. One should avoid too great or too prolonged pressure on the carotid or jugular vein because of the danger of serious hemorrhage.

When the abscess involves the thoracic portion of mediastinum, postural drainage by modified Trendelenburg position is important to assist drainage by gravity.

To overcome dysphagia and promote rest of this area, and particularly if the esophagus is the source of contamination, a feeding tube should be inserted into the stomach at the time of operation so that it can be guided beyond the laceration by the operator. Of particular value here is the double barrel tube such as the Abbott-Rawson through one channel of which feeding can be carried on while the esophageal secretions are constantly aspirated through the other to lessen recontamination by the swallowed saliva. Of course, nothing is given by mouth for the same reason. Nutrition, fluid and chemical balance must be maintained by feeding tube or intravenous administration.

Additional therapy such as the sulfonamide drugs in adequate dosage, neo-arsphenamine if mouth organisms enter the picture, and frequent small blood or plasma transfusions to activate complement and combat anemia and nutritional disturbances help to limit further spread and to hasten cure.

Progress is gauged by clinical means, but must include check-up blood count and x-ray examinations to avoid too early removal of drainage with the possibility of resultant reaccumulation. Unfortunately, one of our patients died from failure to follow this schedule and to determine the extension of the abscess into the thoracic mediastinum. With adequate drainage and supportive measures, patients should recover in from two to four weeks. The pain, dyspnea and dysphagia disappear in a few days, and the temperature usually falls to normal in from five to ten days. Profuse drainage after two weeks or prolongation of more than four weeks usually means stenosis of the drainage tract with inadequate vent.

CASE REPORTS

Case i. H. C., aged fifty-nine, was admitted January 31, 1940. He complained of pain in the renal area radiating to pubes and hematemesis five days before. He felt better on an ulcer diet until the evening of the next day when bloody vomitus recurred with hoarseness and anterior swelling of the neck. On physical examination there was cyanosis, stridor, ulceration of right pyriform sinus and swelling of the neck and supraclavicular regions. Breathing was difficult but there was no increased mediatinal dullness. The day after admission a tracheotomy was performed and adequate drainage obtained by cervical mediastinotomy. X-ray examinations postoperatively showed esophageal perforation and retropharyngeal abscess with extension to the mediastinum. Temperature receded from 102.2°F. immediately postoperative to 98°F. in eleven days, and he was discharged on March 2 without symptoms. (Fig. 3A and B.)

Case ii. G. M., aged nineteen, was admitted May 20, 1936, with the history that

eight days before he had swallowed a denture containing two teeth while eating cream pie. He did not miss the denture until he tried to say

98.3°F. and x-ray revealed gas in the mediastinum, both cervical and thoracic. There was no definite thickening of the retrotracheal
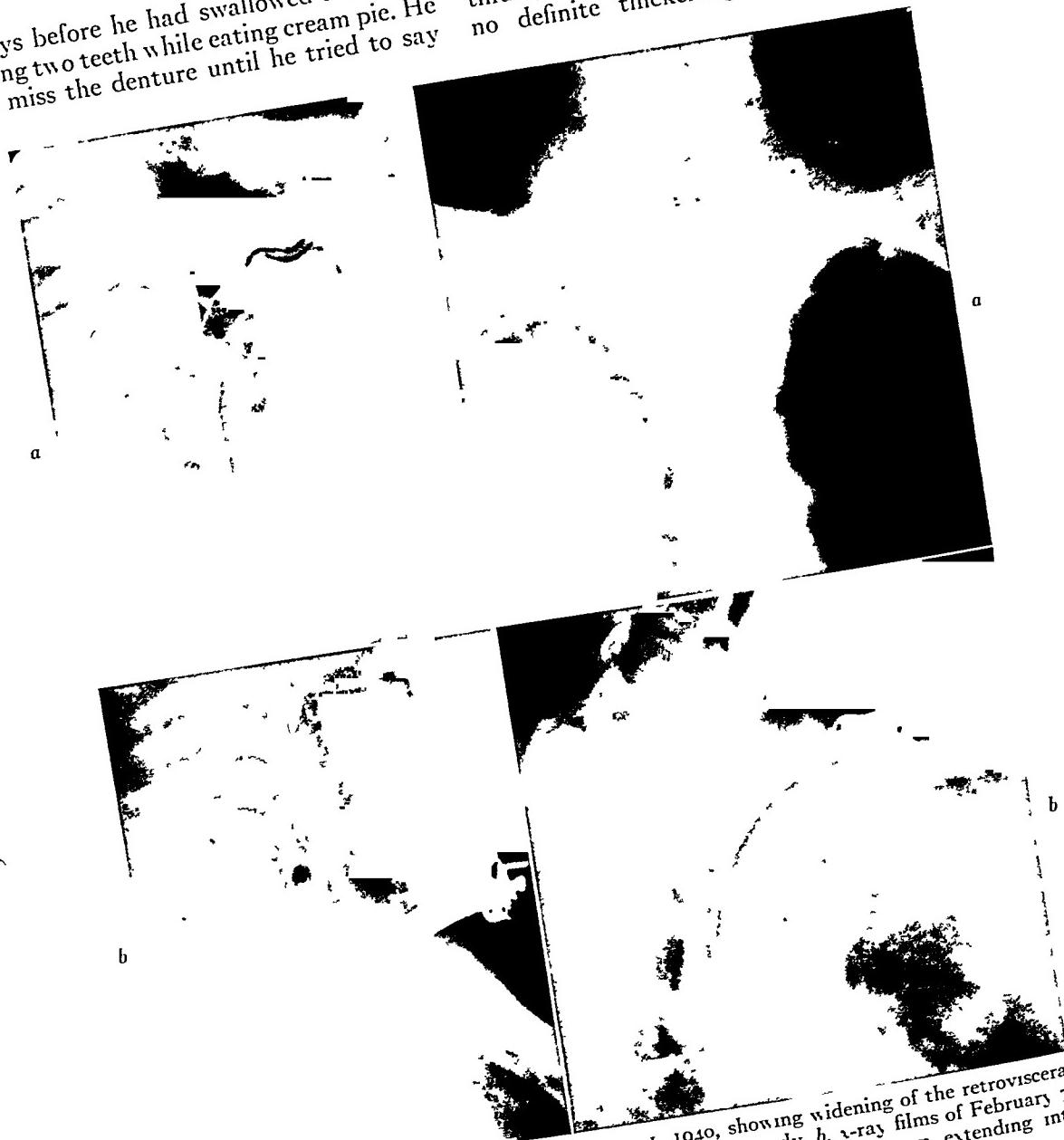
FIG. 3. a, Case I. H. C., x-ray films of February 1, 1940, showing widening of the retrovisceral space with gas extending to the level of the fifth rib posteriorly. b, x-ray films of February 7, 1940, showing tracheal tube, decreased retrovisceral depth, and barium extending into perforation.

"f" or "v." After x-ray, attempt at removal was done in his home town followed by two further unsuccessful attempts, the last under cyclopropane. A few hours later there was hemoptysis and emphysema of the neck with temperature of 101.4°F. Two attacks of cyanosis with irregular heart action occurred in the next two days. On admission temperature was

tissues, but there was a small amount of gas in both pleural spaces. The foreign body was visualized in the neck. There had been marked regression of gas since examinations before admission. Under observation the gas entirely disappeared so that by June 1 none could be demonstrated radiologically. The temperature meanwhile ranged between 98 and 99°F. The

esophagus was observed on several occasions and when sufficient recession of inflammation had occurred an attempt was made to remove the foreign body, but it was found too badly imbedded for safe endoscopic inspection. After another such attempt, external removal by cervical mediastinotomy was done on June 29, six weeks after admission. Operation revealed no pus but there was gray purulent drainage for ten days and the temperature reached normal in twelve days. He was discharged July 15, cured.

CASE III. M. K., aged sixty-nine, was admitted June 21, 1936, for dysphagia of nine weeks' duration due to carcinoma of the esophagus. Physical examination was entirely negative except for a suggestion of mass in the epigastrium. On this day he had a chill which was ascribed to intravenous glucose and the following day biopsy was obtained through the esophagoscope. On July 24, he suffered another chill and fever to 104°F. which subsided for a few days to below 100°F. There was dullness posteriorly in the intrascapular region. Four days later the temperature had continued with additional chill and a tender swelling occurred at the base of the neck with increased width of mediastinal dullness. This increased and on August 3, superficial drainage of a necrotizing infection of the sternomastoid, scalenus, and trapezius muscles was instituted, but the mediastinum was not entered. He died the following day, August 4, and postmortem examination revealed a spontaneous perforation through the esophageal carcinoma with pus in the visceral and retrovisceral spaces.

CASE IV. J. C., aged sixty-four, was admitted January 17, 1938, with hoarseness of two months' duration due to carcinoma of the larynx. On January 20, laryngectomy was done and by January 31, the wound had broken down with considerable sloughing and exposure of infection in the pretracheal tissues. Multiple débridement and attempts at closure of the esophageal fistula were done until April 14, when a portion of necrotic sternum was excised and better drainage of the mediastinum was established. X-ray examination on March 8 revealed widening of the superior mediastinum, a horizontal streak of density above the left diaphragm, and elevation of both leaves of the diaphragm. He was discharged on June 9, with continued drainage, most of which was due to esophageal fistula.

CASE V. F. W., aged fifty-nine, was admitted August 17, 1939, for hoarseness of two and one-half years due to carcinoma of the larynx. On August 24, laryngectomy was done and three days later the temperature rose to 104°F. and remained elevated. Drainage was instituted and on September 1 the wound was opened widely for adequate drainage revealing involvement of the peritracheal tissues in the mediastinum. His temperature continued to rise and he died on September 4. No postmortem examination was obtained.

CASE VI. L. B., aged seventy-two, was admitted January 17, 1937, with fairly extensive carcinoma of the thyroid (microscopically giant cell). On January 19, tracheotomy and thyroidectomy were done. His temperature gradually rose until January 26 when he was dyspneic, had auricular fibrillation, and a foul sloughing wound communicating with the anterior mediastinum. On January 28, x-ray revealed multiple pulmonary metastases. He became progressively worse and died on February 9. Postmortem examination revealed residual carcinoma in the neck, multiple pulmonary metastases, mediastinitis, right empyema and a terminal bronchopneumonia.

CASE VII. G. McD., aged six, was admitted January 14, 1939, with a history of sore throat and stiffness in the neck beginning five days before, and followed on the next day by swelling of the right side of the neck. Two days before her temperature had gone to 104°F., there was vomiting, and the following day dyspnea, cough and pain in the left lower chest. On examination she was cyanotic, dyspneic and there was a tender fullness in the neck anteriorly. The left chest revealed restricted movement, dullness and diminished breath sounds. Her temperature was 102°F. and respiration 44. X-ray revealed mediastinal widening and fluid in the left pleura. She was given prontolin intravenously and sulfapyridine by mouth and her blood concentration varied between 2 and 13 mg. per cent. Fluid was aspirated from the pleura on January 16, 17, and 21, and she was given five transfusions. Cultures of pleural fluid showed Streptococcus hemolyticus. Medication was discontinued on February 12, four weeks after admission because the patient had apparently been cured. She was discharged as cured on February 16 with negative physical examination and x-ray evidence of slight limitation

of diaphragmatic movement but otherwise negative.

CASE VIII. M. C., aged five, was admitted August 17, 1938, for bilateral otitis media and right mastoiditis of three weeks' duration. On August 29, there was considerable nasal discharge, although the ears and mastoid had improved markedly. She developed cough, grunting respiration, and cyanosis and there were abnormal physical signs in the left upper lobe area. X-ray revealed tracheobronchial lymph-node enlargement with obstructive emphysema. This later progressed to atelectasis and by September 6, the left lower lobe was also airless. Several aspirations were unsuccessful in producing fluid, and bronchoscopy revealed huge quantities of pus from the left bronchus containing hemolytic streptococci and fusiform bacilli. The patient was treated by blood transfusion, sulfonamide drugs and neo-arsphenamine, but progressed to death on September 29. X-ray had revealed diminution in the mediastinal width as the suppurative pneumonitis progressed, which was interpreted in retrospect as being due to drainage of the mediastinitis spontaneously into the left upper lobe. The x-ray diagnosis of mediastinal lymph adenopathy and a positive Mantoux test had led to the erroneous diagnosis stated above. No postmortem examination was obtained.

CASE IX. A. B., aged twenty, was admitted May 6, 1938, with a toxic psychosis for which tube feedings were begun. The patient withdrew the tube on two occasions and on May 8, there was considerable difficulty and struggle in reinserting it. The following day, May 9, there was emphysema of the face, neck, thorax and arms. Temperature was 104°F., pulse 160, respiration 20, white blood cells 17,750 with 88 per cent polymorphonuclear neutrophils and of these 38 were nonfilament forms. He was placed on nothing by mouth, sulfanilamide, 100 gr. daily, and daily small blood transfusions. X-ray revealed emphysema but no thickening of the cervical and thoracic mediastinal tissues. There was rapid improvement, the temperature reaching normal in six days, although there were two subsequent rises from May 17 to 21 and from May 23 to June 3, as high as 104°F. on one day, but x-ray revealed no thickening and decreased gas in the mediastinum. Observation over the next three months during which the psychosis improved, showed no further evidence of mediastinal infection.

CASE X. T. C., aged fifty-six, was admitted December 11, 1937, with a three-month history of dysphagia due to carcinoma of the esophagus. Endoscopic examinations were made on December 13 and 16 without difficulty and the constriction visualized. On December 17, temperature rose to 100°F. and there was swelling and tenderness on the left side of the neck along the anterior border of the sternomastoid. This was drained and 5 to 10 cc. of thin odorless pus evacuated, which upon culture was sterile. Seven days later a gastrostomy was done and the patient was discharged on January 15, 1938, with no further evidence of mediastinal infection.

CASE XI. S. W., aged seventy, was admitted February 15, 1938, with a history that she had suffered dysphagia progressively for six weeks and substernal pain for the past two or three weeks. She had lost twenty pounds in weight. Examination revealed temperature of 101°F. with swelling and tenderness of the left side of the neck. White blood cells, 25,000 with 90 per cent polymorphonuclear neutrophils of which 50 were nonfilament. Two days later a gastrostomy for feeding and cervical mediastinotomy were done. On February 19, two days postoperatively, she died suddenly, apparently of a vascular accident.

CASE XII. G. E., aged eight, was admitted November 14, 1935, for laryngeal stenosis of several months' duration. On October 12, 1936, following laryngeal dilatation temperature rose to 102°F. In the next three days it rose in septic fashion to 104°F., and on October 16, 1936, x-ray revealed widening of the retrotracheal space with presence of gas. Cervical mediastinotomy was attempted but no pus could be found and the wound was packed with vaseline gauze. A second attempt on October 23 drained about 60 cc. of thick gray fetid pus and gas. Temperature returned to 99°F. in five days and to normal in eleven days and she continued to complete convalescence.

CASE XIII. A. S., aged forty-four, was admitted May 12, 1939, with a history that all her teeth had been extracted four days before. The following day she awakened with marked swelling of the jaw, fever and general aching. The next day there was swelling of the floor of the mouth and neck with dysphagia and the third day this was increased and she noted pain in the chest substernally and under the left scapula. Examination revealed temperature

102°F., herpes labialis, toxic appearance with foul drainage from tooth sockets and marked swelling of the floor of the mouth preventing observation of the pharynx. There was marked swelling of the left neck and the white blood cells numbered 13,900 with 80 per cent polymorphonuclear neutrophils of which 34 were nonfilament. Smears and cultures showed no spirochetes and many viridans streptococci. Two blood cultures were negative. In the following three days dyspnea appeared and became pronounced, there was one chill, and the patient became dilirious and cyanotic and suffered severe abdominal pain and distention. This picture progressed till her death on May 17. Postmortem examination revealed pus in the retrovisceral space from neck to diaphragm, pericarditis, and bilateral empyema, each space containing more than 100 cc. of gray green pus, cultures of which showed Streptococcus hemolyticus and Streptococcus viridans in aerobic and anerobic culture.

CASE XIV. E. G., aged forty-nine, was admitted March 20, 1938. Nine days before while eating fish, she choked on a bone, since which time there has been sticking pain in the throat. In the past three days pain was severe and there was almost complete dysphagia. Examination showed temperature 99.8°F. with swelling of the mucous membrane of the posterior pharyngeal wall; Wassermann 3, white blood cells 7,700 with 70 per cent polymorphonuclear neutrophils of which 34 were nonfilament. An x-ray revealed retropharyngeal thickening of soft tissues and gas. On March 22, cervical mediastinotomy produced 60 cc. of thick foul pus from about the esophagus. Cultures showed viridans streptococcus and bacteroids. Her temperature reached normal in eight days and she was discharged healed on April 16, four weeks after admission.

CASE XV. R. T., aged seven, was admitted April 5, 1940, with a history of sharp pain in the throat since he had swallowed a sharp object while eating jam two days before. At that time his physician induced vomiting without improvement, and the mother discovered a section of glass missing from the jam jar. Examination revealed temperature 102°F., the patient was unable to move his head or swallow without pain, and there was tenderness over the neck. X-ray revealed a triangular piece of glass and emphysema of the retrovisceral space, both cervical and thoracic. The following day cervi-

cal mediastinotomy was done releasing gas and foul pus, and although the glass fragment was palpated, it was dislodged and moved down the esophagus preventing removal. His temperature fell to normal in five days, April 11, and he passed the glass by rectum. Sulfapyridine was administered for one day but was discontinued because of hematuria. He was discharged April 26 with a healed wound as cured.

CASE XVI. J. S., aged forty-six, was admitted September 2, 1937, with a history that ten days before, while eating crab meat, he had swallowed a piece of shell. This caused coughing and a cutting pain in the throat with pain in the chest which persisted to admission. On examination, temperature was 101°F., pulse 100, respiration 30, but no physical signs could be found in the neck or the thorax. Esophagoscopy revealed esophagitis with ulceration. The following day there was more pain and emphysema with tenderness in the left neck anteriorly. The next day white blood cells 19,300, with 75 per cent polymorphonuclear neutrophils of which 15 were nonfilament forms, and x-ray revealed retrovisceral thickening and gas. In the next seven days there was steady improvement and he was discharged for observation as an outpatient. On September 15, the throat became very sore and in a few hours he coughed up a large quantity of pus. He was readmitted the following day, September 16, with marked dysphagia and induration along the anterior border of the left sternomastoid. The following day cervical mediastinotomy was done releasing gas and foul pus under tension. The temperature dropped from 101 to 98°F. in two days and he was discharged on September 24 improved.

CASE XVII. A. W., aged forty-two, was admitted May 13, 1937, for esophageal stenosis of unknown etiology. She was examined endoscopically and the next day her temperature rose to 102°F. The following day x-ray revealed retrotracheal thickening and gas, and barium penetrating the esophageal wall. However, temperature slowly subsided and there was general improvement except for x-ray evidence on May 19 of increased gas and swelling in the retrovisceral space with narrowing of the trachea from outside pressure on the right. On May 21, eight days after the onset a cervical mediastinotomy was done releasing fetid yellowish gray pus from the retrovisceral space. Her convalescence was good until June 2, her

twelve postoperative day. In the next twenty hours she had three rather severe hemorrhages requiring secondary operation on June 3. This

Case xix. G. B., aged fifty-four, was admitted October 9, 1939, for dilatation of cardiospasm associated with hiatal hernia. On
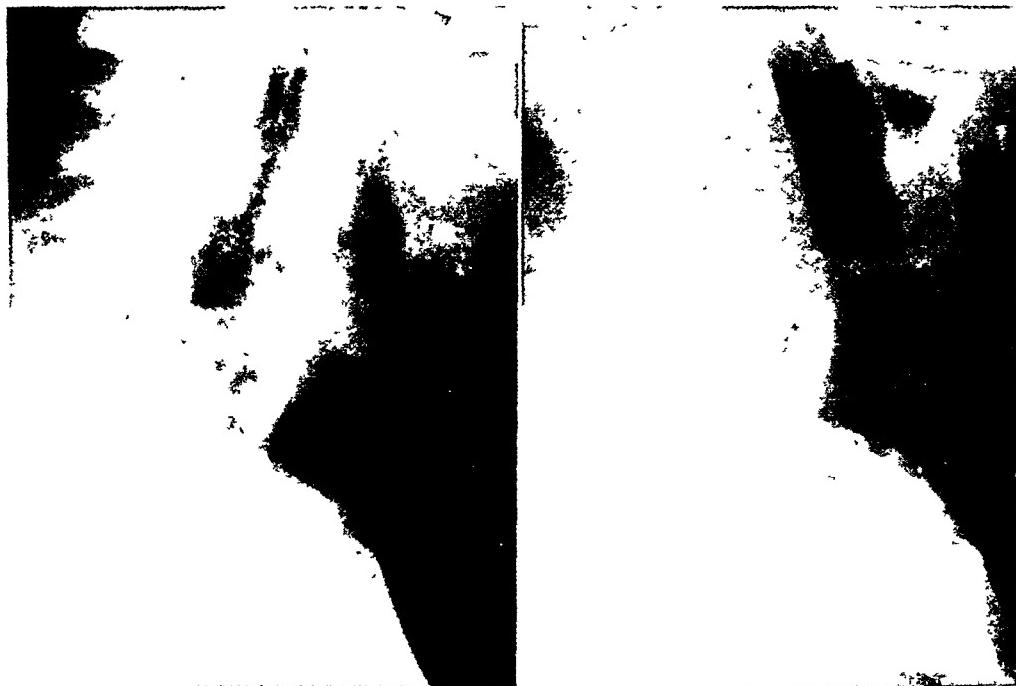
Fig. 4. Case xix. G. B., left, x-ray film of October 14, 1939, showing extensive retrovisceral thickening and gas. Right, x-ray film of February 2, 1940, showing decreased depth and gas.

showed a slough of the carotid artery which required ligation of same for control. She developed a hemiplegia from loss of cranial blood supply and died the following day. Postmortem examination revealed continued posterior mediastinitis, fibrinous pleurisy but no fluid on the left and softening of the right cerebral hemisphere.

Case xviii. K. C., aged seventy-five, was admitted January 27, 1939, with a history of swallowing a fish bone five days before. For two days there had been severe pain on swallowing which then decreased. For the past three days she had fever and pain in the right upper chest anteriorly. Examination showed temperature of 100.4°F. and tenderness in the neck anteriorly. There were 14,800 white blood cells of which -- per cent were polymorphonuclear neutrophils and 30 of these nonfilament forms, and blood sugar of 270. On January 28, cervical mediastinotomy was done releasing about 60 cc. of odorous pus and gas from the retrovisceral space. Temperature receded to normal in ten days and she was discharged February 12, 1939, as cured.

October 12, esophagoscopic dilatation was done and two days later there was pain, tenderness, swelling and emphysema in the left neck anteriorly. White blood cells, 5,800 of which 88 per cent were polymorphonuclear neutrophils and 28 of these nonfilament forms. The x-ray revealed peritracheal gas and phlegmon. The following morning, October 15, the patient was delirious and cervical mediastinotomy was done releasing 10 to 15 cc. of foul brownish pus from the retrovisceral space. Temperature dropped to normal in eleven days but drainage persisted due to esophageal fistula. The purulent character disappeared within two weeks and healing was complete in 2 months. (Fig. 4.)

Case xx. D. S., aged seventeen, was admitted May 14, 1937, with a history of swallowing a chicken bone a few hours before. Sticking pain had been present since. Temperature was 100°F. and there was slight tenderness in the neck. During esophagoscopy the bone passed on down the esophagus. Temperature increased to 102°F. and there was evidence by x-ray of gas in the mediastinum and left pleura and a white blood count of 17,000 with 85 per cent poly-

morphonuclear neutrophils of which 50 were nonfilament forms on May 15. On May 17, fluid was found in the left pleura and this was drained on May 18 by intercostal drainage revealing foul gray pus and gas. No mediastinotomy was done. The patient made slight temporary improvement followed by steady regression and finally hemorrhagic drainage through the thoracostomy ended in death on May 25.

CASE XXI. K. M., aged thirty-eight, was admitted January 1, 1937, with a history that eleven days before while eating a veal cutlet a sharp object stuck in his throat. A physician and x-ray examination could find nothing abnormal. Six days later a lump appeared on the neck along the anterior border of the sternomastoid and two days later he began to expectorate foul pus. Additional x-ray revealed a piece of wire in the esophageal wall, and he was sent to the hospital. Examination revealed temperature 101°F., swelling on both sides of the neck more marked on the right which was tender and caused pain radiating to the right arm. Swallowing caused similar pain. The following day, twelve days after onset, cervical mediastinotomy revealed 15 cc. of fetid gray pus and a piece of wire. On January 13, temperature was normal, there was very little drainage, and the patient was symptom free. He was discharged to the care of his family physician. (Fig. 5.)

CASE XXII. S. D., aged four was admitted April 1, 1938, with history of swallowing catsup bottle top seven days before. There was choking and cyanosis for a short time followed by vomiting and anorexia. Removal was attempted before admission following which there was cough and cyanosis. Examination revealed temperature of 101°F. with some reddening in the pharynx but no swelling or emphysema of the neck. There were a few rales over the right lower lobe area. White blood cells 18,400 with 42 per cent polymorphonuclear neutrophils of which 21 were nonfilament Four days later x-ray showed foreign body had moved into the stomach. There was a marked increase in temperature to 104°F. and in the white blood cells to 90,000 with 56 per cent polymorphonuclear neutrophils of which 45 were nonfilament. Two days later she was extremely toxic. There was no emphysema of the neck and x-ray showed widening of the mediastinum and the presence of gas. In this critical condition cervi-

cal mediastinotomy was done and thick cloudy fluid with considerable cellulitis and edema was revealed which showed a culture of hemolytic streptococcus. She died the same day, April 6, 1938.

CASE XXIII. J. T., aged fifty-seven, was admitted July 12, 1937, for a carcinoma of the esophagus producing symptoms over the past six months. Following biopsy on July 12, the patient slowly developed temperature to 101°F. over the next three days with subcutaneous emphysema of the neck and x-ray evidence of retrotracheal widening and gas. There was also an increase of the lung marking on the left as compared to previous films. Two days later, July 17, there was increase in symptoms and local evidence and a cervical mediastinotomy was productive of foul pus and gas. Following this the patient improved rapidly over a period of two weeks and was discharged with continued drainage and without x-ray check-up. He was readmitted on September 10, 1937, seven weeks after mediastinotomy with a healed mediastinotomy and increasing dysphagia which was ascribed to his carcinoma. On September 11, a gastrostomy was done. On September 15, the patient had circulatory collapse with pain in the chest and left lower abdominal quadrant and physical signs suggesting atelectasis at the left base. X-ray revealed evidence of atelectasis or pneumonitis left base. The patient became progressively worse and died on September 25, having been moribund for five days. Postmortem examination revealed 400 cc. of thick foul pus in the posterior mediastinal space, purulent pericarditis and hemorrhagic effusion in both pleura, 800 cc. on one side and 1,800 on the other.

CASE XXIV. H. B., aged eighteen months, was admitted December 28, 1938, two months after she had swallowed lye, with increasing difficulty in swallowing since. Her temperature was 101°F., physical examination negative and white blood cells, 16,500 with 40 per cent polymorphonuclear neutrophils of which 14 were nonfilament. On December 30, esophagoscopy showed ulceration and swelling of the mucosa. Immediately after the patient began vomiting and within four hours there was fever of 103°F., cyanosis, and labored breathing. This progressed rapidly, there was emphysema of neck and x-ray evidence of gas in the mediastinum, pericardium, and left pleura. Aspiration removed 40 cc. of milky fluid and gas from the

left pleura and similar material from the pericardium. Cultures of these showed hemolytic staphylococcus aureus and non-hemolytic

pain in the left ear which had been host to otitis media at the age of three and again at the age of eight. His temperature was 99 to 100°F., pulse
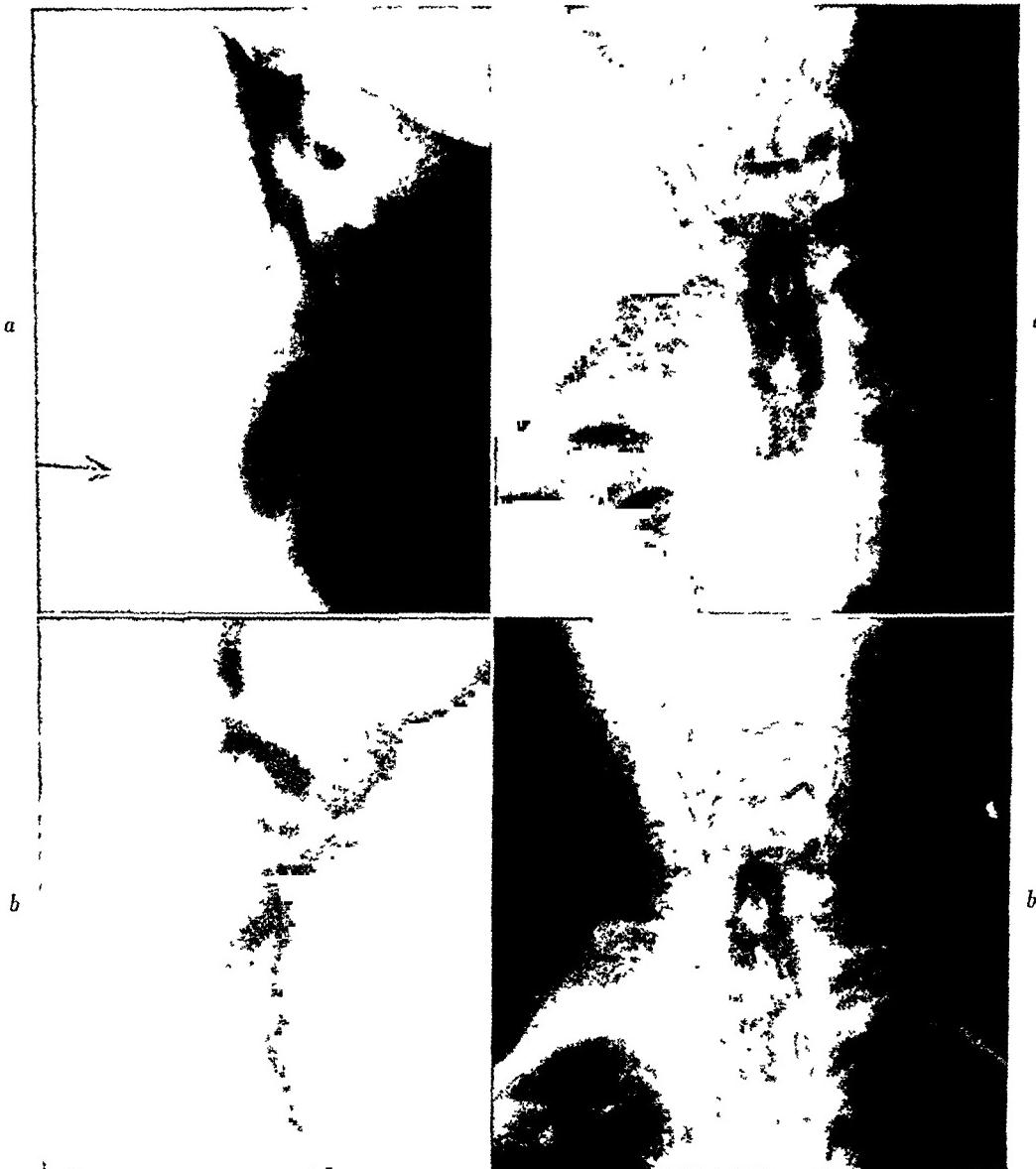
FIG. 5. a, Case XXI. K. M., x-ray films of January 2, 1937, showing thickening of the retrovisceral space extending to the fifth rib posteriorly with gas and wire. b, x-ray films of January 12, 1937, showing decreased depth and gas and three wire sutures.

streptococcus on both aerobic and anaerobic culture. The child was too ill to consider the multiple surgical procedures necessary for drainage and died in the next seven hours, December 31, 1938. (Fig. 6.)

CASE XXV. C. VanF., aged twenty-five, was admitted November 3, 1939, with a history of sore throat and swelling anterior to the left mastoid beginning eight days before. He had

74 and respiration 20. The pharyngeal wall, uvula, and left tonsillar fossa were red and swollen. There was poor dental hygiene and neck was hot, tender and indurated in the left anterior portion from the mandible to the base of the neck. The following day, November 4, a quantity of foul smelling pus was evacuated by superficial incision and apparently the character of the abscess was not recognized. Culture

showed Streptococcus viridans on aerobic and hemolytic streptococcus and bacteroids on anaerobic culture. Profuse drainage continued

hemolytic staphylococcus aureus. His tempera-ture returned to normal in five days and his progress was good. On December 13, opaque
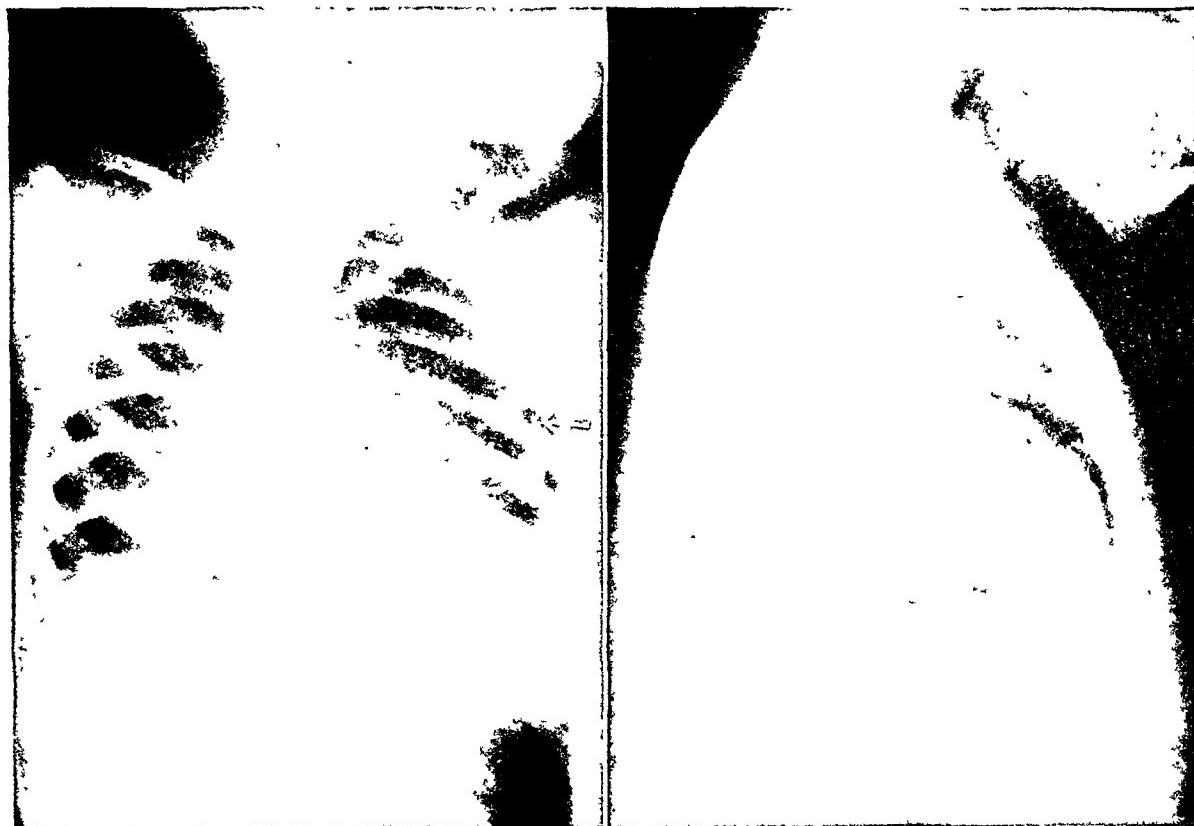
Fig. 6. Case xxiv. H. B., x-ray films of December 30, 1938, showing extensive mediastinal emphysema extending from skull to diaphragm, left hydropneumothorax and hydropneumopericardium.

for three days then decreased, and he was dis-charged six days later as improved.

He was readmitted December 1, three weeks later, stating that for one week after discharge he improved but was constantly hoarse. One week ago the slight pain on swallowing which he had suffered increased as did the hoarseness. One half hour before admission severe cough, dyspnea and some hemoptysis had occurred, and he was rushed to the hospital by his physi-cian. Examination showed marked dyspnea and cyanosis and continued drainage from the cervical wound. Mirror laryngoscopy revealed fixation in adduction of both vocal cords with displacement of the larynx to the right. Emergency tracheotomy was done with marked relief. On December 2, x-ray revealed gas and phlegmon of the retrovisceral and visceral spaces—not communicating with tracheotomy wound. Displacement of the trachea to the right was also demonstrated. There were 10,800 white blood cells with 65 per cent polymorpho-nuclear neutrophils, 13 of which were nonfila-ment. Culture from the drainage revealed

material was introduced through the cervical wound and x-ray taken outlining the retro-visceral space from the clavicle to the base of the skull. He was again discharged on Decem-ber 22, with continued cervical drainage so that he might spend the Christmas holidays at home. He was readmitted on January 4 in the same condition. Because of persisting drainage the cervical wound was enlarged on January 17, 1940, and he was discharged on February 5 with lessened drainage continued paralysis of the cords and swelling of the epiglottic and sub-glottic regions. Treatment was continued over the next year for laryngeal stenosis requiring wearing of the tracheotomy tube. X-ray of August 30, 1940 showed persistence of soft tissue swelling about the larynx, chiefly to the right.

CASE xxvi. H. S., aged twenty-three, was admitted June 5, 1937, with a history of extrac-tion of the first left lower molar four days ago. Two days later there was swelling and pain in the left submaxillary area which has progressed to trismus and swelling under the tongue.

Examination revealed pus exuding from the swollen socket, trismus and tenderness with induration in the left submaxillary region extending in lessened degree to the left clavicle. There was also marked lymphadenopathy on this side, temperature 101°F., pulse 110, respiration 22. Culture showed Streptococcus viridans. He was given sulfanilamide 90 gr. daily, blood transfusions, and ice bag to the affected area, following which there was rapid and marked improvement so that the surgical drainage planned for the following day was postponed. Temperature reached normal in three days and he was discharged June 11 as cured.

CASE. XXVII. R. DiG., aged forty-six, was admitted April · 17, 1940, seven days after toothache began in the right lower third molar. The following day there was swelling about the mandible which increased, and two days later chills and fever occurred. The next day the tooth was extracted and much pus evacuated. However, the swelling increased, fever persisted and respiratory difficulty occurred just before admission. Examination showed swelling of the lateral and posterior pharyngeal wall, the floor of the mouth, and the entire neck anteriorly. The appearance of the gums suggested Vincent's angina and there was very poor dental hygiene. The patient was cyanotic and in a state of vascular collapse. The temperature was 101°F., pulse 140, respiration 50, white blood cells 13,450 with 89 per cent polymorphonuclear neutrophils of which 61 were nonfilament forms. X-ray revealed retropharyngeal and posterior mediastinal induration, and possible bronchopneumonia of the left lower lobe. He died within a few hours before anything could be done except the administration of sulfanilamide for two or three doses. Postmortem examination revealed Ludwig's angina, lateral pharyngeal space and retropharyngeal abscess extending into the posterior mediastinum, pericarditis and bilateral empyema. Blood cultures were overgrown with contaminants.

CASE XXVIII. L. S., aged forty-seven, was admitted January 13, 1937, with a history that four days before a chicken bone had stuck in his throat causing temporary choking. He made an effort to remove it with his finger but the symptoms persisted. That night there was dyspnea on lying down and at 4 A.M. his doctor tried to force the bone down the esophagus. Two days before admission x-ray revealed the bone and an attempt at esophagoscopical removal was unsuccessful. Since that time the patient was unable to swallow and there was pain in the throat and chest for which he was referred to the hospital. Examination revealed temperature 98.4°F., pulse 84, and respiration 22 with no swelling or tenderness of the neck but a swollen posterior pharyngeal wall. X-ray revealed retrovisceral phlegmon and gas and an opaque area suggestive of bone. Barium penetrated the posterior pharyngeal wall. He improved and was discharged on January 16 to his family physician. One month later he coughed up a portion of tooth-pick measuring two and one-half inches with complete relief except for occasional choking sensation over the past five months.

CONCLUSIONS

Acute mediastinitis is a fairly common disease as indicated by published reports and thirty-eight cases at Temple University Hospital in five years.

Knowledge of the practical anatomy of the fascial planes of the neck and thorax as reviewed is of vital importance.

Analysis of the etiology, symptoms, and results of our cases compared with 197 cases collected from the literature indicates that the mortality of undrained cases ranges between 60 and 80 per cent and that for the group in which adequate drainage was established varies between 33⅓ and 40 per cent.

Accurate diagnosis is possible if the lesion is considered in potential cases. X-ray study has been the most dependable method of investigation.

Immediate drainage by cervical mediastinotomy with the additional supportive measures outlined offers the best prospect for cure.

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A GOITER fixed by capsular infiltration which makes the technic difficult is more liable to lead to disaster than those in which the gland is freely movable. Therefore if the gland is fixed, one had better wait until it loosens.

LOGICAL APPROACH TO SUBPHRENIC ABSCESS*

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A DISCUSSION that deals with thoracic surgery connotes a consideration of pathology above the diaphragm, but it is obvious when we consider the exact location of this structure that the region immediately below it is likewise well within the boundaries of the thoracic cage. For this reason the subject of subphrenic abscess is included in this volume, and the following presentation based on 124 consecutive operative cases covering the period from 1900 to 1941, from the Massachusetts General and associated Baker Memorial Hospitals is presented.

Objection might be raised that a study extending back to such an early period includes certain cases that were of necessity handled without the aid of modern surgical adjuncts. In an attempt to present the logical approach to the treatment of this condition, however, the inclusion of these earlier cases would seem helpful in affording a background for the evolution of present beliefs. Furthermore, with the single exception of the advances made in x-ray technic, there have been no outstanding surgical contributions that alter the fundamental considerations that this problem presented in this series.

Any study at a single institution over a lesser period would be productive of so relatively few cases that the statistical value of the data would tend to be limited and misleading. The cases involving those spaces beneath the liver edge that have come by common acceptance to be included under the term "subphrenic abscess" are likewise included; for although, strictly speaking, they lie below the thorax, they are so intimately associated both from an anatomic and a therapeutic point of view with the areas above the liver that they cannot well be dissociated from them.

It may seem trite to state that the most desirable surgical procedure in the treatment of an abscess which has been correctly diagnosed is that which promptly gives the most effective dependent drainage through the shortest approach consistent with the safety of the intervening structures. Certainly these general principles present no problem if we consider such a simple example as that presented by an axillary abscess. In the case of a subphrenic space involvement, however, the various factors mentioned are more complex and for that reason will be considered separately in greater detail.

STATUS OF INFECTION

In the case of a superficial infection, the stage of its development can be readily evaluated by palpation and the presence of fluctuation detected. However, with a subdiaphragmatic involvement, because of the resistance of the overlying ribs, the process does not permit such evaluation, and the question as to whether such infection has progressed to suppuration is often a difficult one to answer. It is well recognized that if frank pus in the subphrenic region is not drained surgically or does not rupture spontaneously into some favorable avenue of escape, the mortality will approximate 100 per cent. It does not necessarily follow that because there is inflammation beneath the diaphragm it will progress to abscess formation; in fact, Ochsner and Graves[1] state that over two-thirds of such infections subside without suppuration, and in this present series, one-fifth (20 per cent) of the cases with clinical signs of such infection followed a similar course. (Table 1.) Undoubtedly, many instances in which such a process was suspected but of necessity lacked con-

firmation failed to have such a diagnosis entered on their records, and thus the proportion of such cases errs in being too low in this present series.

TABLE I
CASES DIAGNOSED AS SUBPHRENIC ABSCESS
OR SUBPHRENIC INFLAMMATION

Classification of Case	No. of Cases
Surgical drainage of subphrenic abscess	124
No operation (subphrenic inflammation)	32
No operation for subdiaphragmatic abscess (lesion discovered at autopsy)	23
Operation but no pus encountered	6
Spontaneously drained via previous operative sinus	4
Total	189

In twenty-three cases in which no drainage of the subphrenic area had been instituted, autopsy examination revealed in one of the subdiaphragmatic spaces a collection of pus which in most instances was small in amount and of incidental importance as a cause of death.

Doubt is bound to exist in certain cases on the question of the actual presence or absence of pus, and in 6 instances of this series, the subphrenic region was explored and no abscess encountered. An occasional such properly executed exploration that reveals only "subphrenic inflammation" is infinitely more desirable than a timid attitude of vacillation that allows the process to persist unduly long or extend beyond its natural confines.

Spontaneous drainage occurred in four patients along the course of an apparently healed sinus tract that had resulted from the institution of drainage at the time of the original laparotomy.

ANATOMY

It is not surprising that considerable ambiguity should exist in the minds of many surgeons as to the exact limits of the constant subdivisions of the space beneath the diaphragm, for they are called upon relatively infrequently to explore certain areas of this region. In this series, for example, fifty-five surgeons were responsible for the treatment of the 124 patients

and the greatest number drained by any one individual was only ten. The prime requisite, however, for prompt recognition and intelligent treatment of a subdiaphragmatic abscess is a thorough familiarity with the anatomy involved; for a diagnosis which localizes the infection beneath the diaphragm yet fails to specify which of the spaces it involves is bound to be attended with hesitancy in proceeding with surgery and relative ineffectiveness when it is finally adopted.

Martinet[2] and Barnard[3] at the start of the century presented such effective anatomical descriptions of this area that these have subsequently served as a basis for defining the limits of what is now understood to be included under the term "subphrenic region." Beneath the diaphragm the falciform suspensory ligament divides the area superior to the liver into two essentially equal right and left portions. (Fig. 1.)[4] On the left, there is but a single superior space as the triangular ligament of the liver does not encroach upon its surface but is attached to the posterior margin of the left lobe. On the right, the falciform ligament and its lateral extension divides the area into a right posterior superior space, and a retroperitoneal area within the laterally converging leaves of the ligament itself. (Fig. 2.)[4] Special note should be made that the anterior space is far larger than the posterior by virtue of the fact that the anterior portion of the triangular ligament lies well posterior to the dome of the liver, and that the posterior portion of the ligament by its dorsal obliquity restricts the right posterior space to a distinctly lateral position. (Fig. 3.) A retroperitoneal area that may become distended with pus exists between the diaphragm and diaphragmatic peritoneum; but this is a potential rather than a truly anatomic space, and infection in this region played a relatively minor rôle as this space was involved in but 3 per cent of these cases.

Beneath the liver on the right is a single right inferior space, less well demarcated

than those already referred to, yet none the less definitely bounded by the liver above, the round ligament and the ligament of

of thirty-eight years in this series and a preponderance of males (62 per cent) being merely a reflection of the group in which
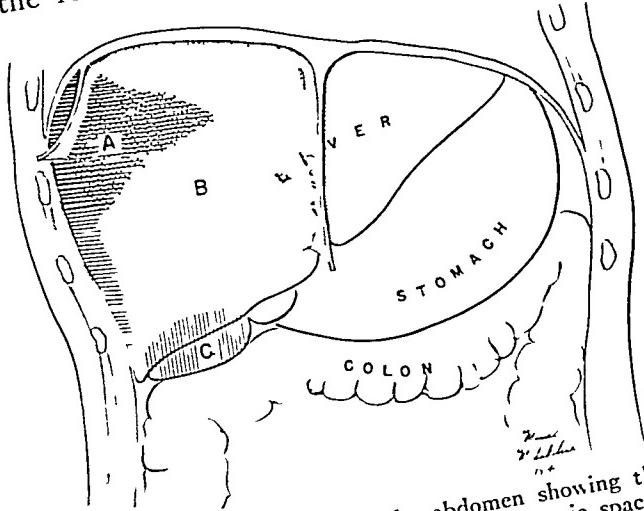
FIG. 1. Anterior view of the abdomen showing the three most commonly involved subphrenic spaces. A, right posterosuperior; B, right anterosuperior; C, right inferior. Actually the shaded portions of A and C lie behind the substance of the liver. (Faxon.[4])

FIG. 2. Sagittal view of the right abdomen showing the three most commonly involved subphrenic spaces. A, right posterosuperior; B, right anterosuperior; C, right inferior. (Faxon.[4])

the ductus venosus medially, the transverse colon below and the kidney posteriorly. On the left of the midline are two inferior spaces, the lesser peritoneal cavity which constitutes the left inferior posterior space, and the region anterior to this known as the left anterior inferior space with the liver above, the stomach below and the gastrohepatic omentum posteriorly.

DIAGNOSIS

Although certain reports would suggest that detection of a subphrenic abscess is easily accomplished, the writer's personal review of the records of these cases emphasizes the fact that in numerous instances great uncertainty existed in the mind of the surgeon as to whether infection was indeed present in the region of the diaphragm, and if so, whether it was above or below that structure. Even when he had satisfied himself that pus probably existed in one of the subphrenic spaces, he frequently was at a loss as to which of these was involved.

The age and sex of the individual were of no material diagnostic aid, the average age

the various inciting causes of such abscesses are most prevalent.

Consideration of the diagnosis should be entertained in cases with unexplained clinical findings of localized infection in whom the presence of an antecedent intraperitoneal infection has been established or initiated by previous surgery, or in those unoperated cases in which the occurrence of such intraperitoneal sepsis has been strongly suspected. In one third (33 per cent) of the cases of this series, no previous surgery had been carried out, and the etiology was in some doubt in all save one-quarter (27 per cent) of these in which the history was perfectly characteristic of some given pathology.

In this series, appendiceal peritonitis most commonly furnished the primary source (31 per cent), with lesions of the stomach and duodenum second and of almost equal importance (30 per cent), and those of the liver and bile passages third (19 per cent). (Table II.) In the case of the

latter two sources, their close proximity to the subdiaphragmatic region makes the direct extension of infection to that area

lymphatics or blood stream, there was no instance in this series in which the implantation of sepsis by either of these
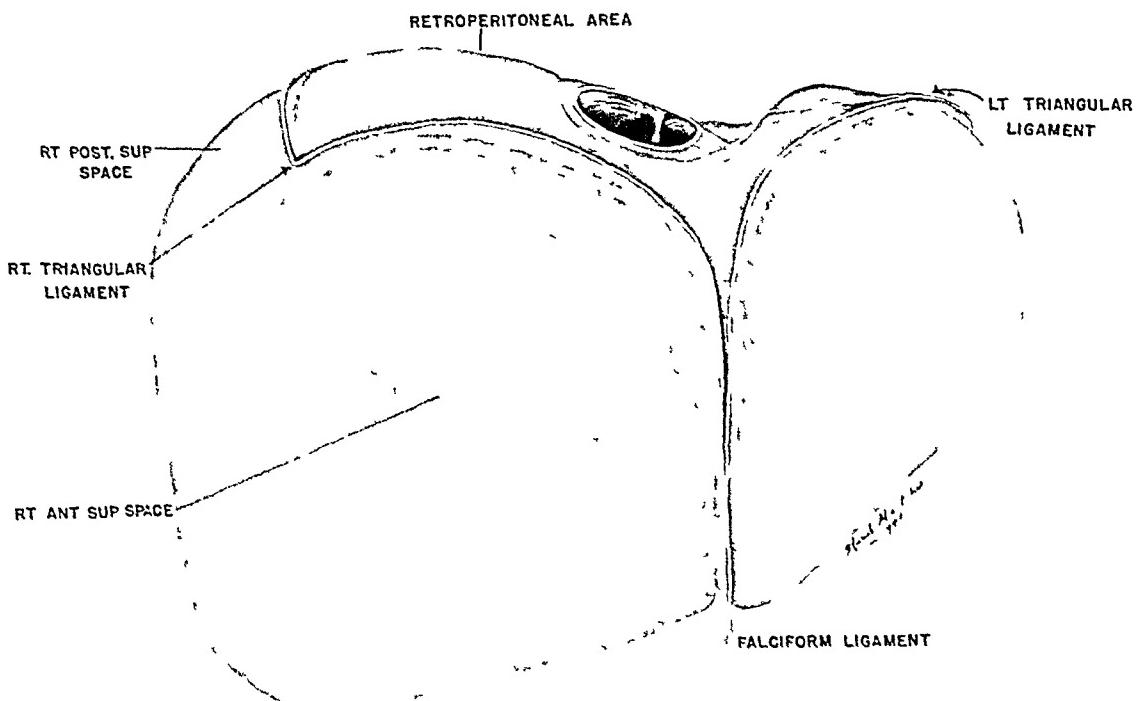
Fig. 3. View of the superior surface of the liver showing how the diverging leaves of the right triangular ligament limit the size and position of the most commonly involved posterosuperior space.

easily understandable. When appendicitis has been the inciting cause, the spread of infection from the distinctly more remote right gutter is best explained by the aspirating influence of respiration in the upper abdomen demonstrated by Overholt,[5] and the part the ventral curvature of the lumbar spine, with the patient in the supine position, plays in influencing the gravitation of material toward the subdiaphragmatic region.

TABLE II
ETIOLOGY OF SUBPHRENIC ABSCESS

	Cases	Percentage
Appendix	38	31
Stomach and duodenum	37	30
Liver and bile passages	24	19
All other causes	25	20

Although infection may find its way to one of the subphrenic spaces by way of the

routes could be clearly established. In the cases in which an empyema was found in association with the subdiaphragmatic abscess, it seemed in all save possibly two cases to have been a result rather than a primary cause of the subphrenic abscess.

Granted a case in which a subphrenic abscess is suspected, the likelihood of its being present is strengthened by the finding of certain or all of the following factors: a high fixed diaphragm, fluid or gas beneath that structure, tenderness over a suspected space, and pleural effusion.

The position and motion of the diaphragm can be approximately determined by clinical examination of the chest, but fluoroscopic studies give more exact information on these points and in addition establish the presence or absence of fluid or gas in the upper abdomen. When the patient is too ill to permit such an examination, portable roentgenograms should be taken in both the anterio-posterior and lateral views with the patient's trunk sup-

ported in an upright position. X-ray facilities during the early part of this series were much more limited than in recent

FIG. 4. Drawing of the initial steps in the retroperitoneal type of operation for a right posterior or inferior space infection. Note that the deeper dissection is at a level of the first lumbar spine rather than along the bed of the twelfth rib.

years, which explains the fact that in twenty-eight cases no roentgenological studies were made. In five cases, a sinus tract which had persisted following previous operative drainage was effectively utilized for the injection of a radio-opaque material to demonstrate the confines of the abscess cavity. (Table III.)

TABLE III
X-RAY DATA IN NINETY-SIX CASES*
OF SUBPHRENIC ABSCESS

	Cases	Percentage
Diaphragm elevated................	75	78
Diaphragm not elevated..	4	4
Diaphragm not visualized	17	18
Fluid level and gas.................	28†	29
Opaque injection into sinus..........	5	5

* In twenty-eight cases no preoperative x-ray films were taken.
† One of these cases showed no fluid level, although gas could be demonstrated.

In nearly one-fifth (18 per cent) of the ninety-six cases in which x-ray studies were made, the outline of the diaphragm was obscured. When the diaphragm could be visualized, however, it was found to be elevated in practically all (95 per cent) of

the cases. The erroneous idea is frequently entertained that gas and a fluid level can usually be demonstrated in a subphrenic
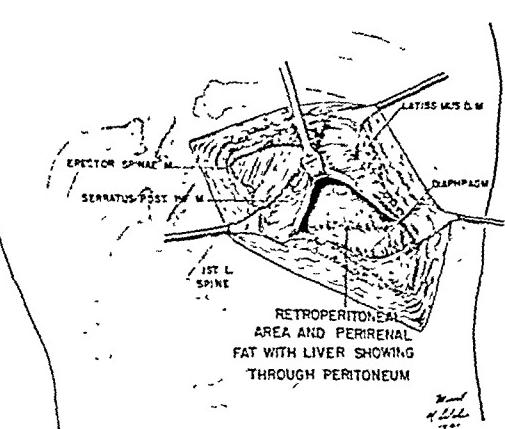
FIG. 5. Drawing of a later stage in the retroperitoneal type of operation for a right posterior or inferior space infection. Note that the lower fibers of the diaphragm have been cut across but that the peritoneum has not been incised.

abscess, when, as a matter of fact, this was true in but slightly over one-quarter (29 per cent) of the cases in which roentgenograms were taken. Muller et al.,[6] have demonstrated that free air beneath the diaphragm can be visualized by x-ray as long as two weeks following laparotomy, so that the possibilities for its presence must be weighed in order to attribute the proper significance to the finding.

That the type of contamination was the most important factor in the occurrence of fluid and gas in the subphrenic abscess is brought out by the fact that nearly one-half (thirteen) of the cases with this finding followed a perforated gastric ulcer in which gas and fluid played a part at the time of the initial insult to the peritoneal cavity. There were, however, an equal number (thirteen) of subdiaphragmatic abscesses following perforation of a gastric or duodenal lesion in which no such finding was present. Neglect in instituting drainage could not be shown statistically to account for fluid and gas for the cases in which these were present were actually drained earlier following their initial infection (twenty-two days) than those in which they were absent (twenty-seven days).

As with circumscribed infections in other conditions, localized tenderness is of great diagnostic significance in a suspected case

ally demonstrated, it undoubtedly may have existed. In over two-thirds (72 per cent) of the cases, however, in which
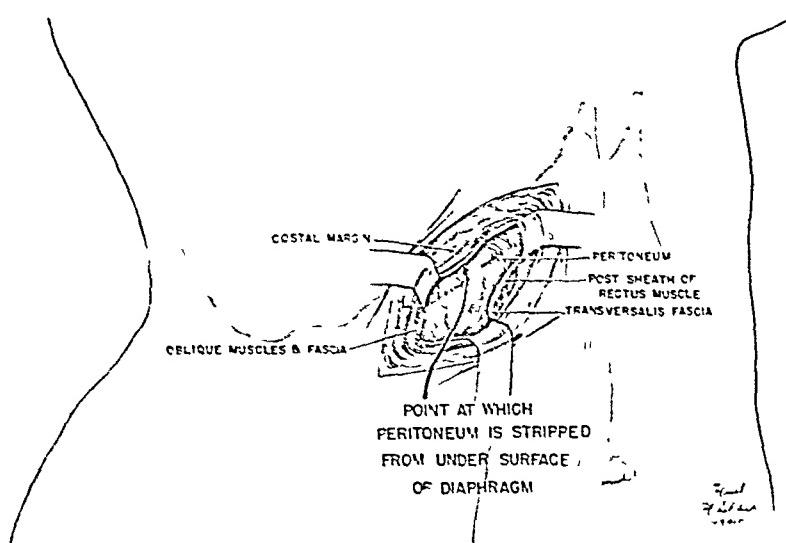
FIG. 6. Drawing of the initial steps in the retroperitoneal type of operation for an anterior space infection. Note that the posterior fascial layers must be incised before the peritoneum can be stripped from the undersurface of the diaphragm.

of subphrenic abscess. Inasmuch as with involvement of the superior spaces the thoracic cage intervenes as a barrier between the skin and the underlying infection, it is frequently easier to elicit tenderness by compression of the chest wall than by any lighter forms of palpation. Careful interpretation of the findings of such examination is helpful in further suggesting which of the spaces is involved, for with the abscess in the right posterior superior space, tenderness will be found over the twelfth rib posteriorly; while with infection in the anterior superior spaces, it will be brought out by firm pressure over the respective right and left anterior costal margins.

The finding of pleural effusion may be more confusing than helpful in arriving at the proper diagnosis, for its presence may be mistakenly ascribed to a primary source of infection above the diaphragm. Opinions[1,7,8] differ as to the frequency with which fluid is found above the diaphragm in association with a subphrenic abscess. The data from this series of cases are inconclusive on this point, for in a definite number of the eighty-two cases in which there was no note of such fluid being actu-

thoracentesis or visualization of the pleural cavity was carried out, some pleural effusion was apparently present and was usually (87 per cent) found in conjunction with an abscess involving one of the superior spaces. (Table IV.) That it did not of

TABLE IV

FINDINGS AS REGARDS PLEURAL EFFUSION ASSOCIATED WITH SUBPHRENIC ABSCESS

Clinical Data	Number of Cases	Percentage of Total Cases
No thoracentesis or operative visualization of pleural cavity............	82	66
Empyema at time of subphrenic drainage.........................	10*	8
No fluid by thoracentesis (4) or visualization (5).................	9	7
Pleural effusion by thoracentesis (23) or visualization (0)........	23†	19

* 70 per cent of these were grossly neglected cases occurring prior to 1924.

† 87 per cent of these involved one of the superior spaces.

necessity occur in the late neglected cases is suggested by the fact that in the patients in which it was demonstrated, and who were operated upon for their original

pathological condition at the same hospital entry at which the abscess was drained, the elapsed time from the inciting cause to the drainage of the abscess (twenty-nine days) was essentially the same as in those in which there had been no demonstrable evidence of any pleural effusion (thirty days). These intervals in this series of cases between the time of contamination of the subphrenic region and the institution of drainage have remained disturbingly constant over the years and are distressingly long, for they reflect delay and difficulties in diagnosis rather than the actual time that it takes for such an abscess to become established.

The practice of thoracentesis in a case in which pleural effusion is suspected by clinical examination or x-ray studies is an altogether justifiable procedure to differentiate between an empyema and a simple effusion. If this procedure is adopted, special care should be exercised to avoid penetrating the diaphragm in a further search for an abscess beneath that structure, for if such is encountered and the then contaminated needle be withdrawn through an uninvolved serous cavity, the added complication of empyema or peritonitis will frequently result. Preoperative exploratory aspiration of the subphrenic spaces for this reason is never justifiable, but if employed in the face of this objection it contributes information only if pus is actually secured, for it cannot be assumed because of a failure to obtain pus that no abscess is present. It is of some suggestive interest that the mortality rate (66 per cent) was approximately twice as great in the twelve cases in which it was practiced preoperatively as it was both in the cases in which it was not adopted (33 per cent) and in those in which aspiration was done with relative safety under direct vision at the time of operation (36 per cent). From a study of the records, it is seen that this difference in mortality was in part due to the complications attendant on such ill advised, blind explorations, but it is only fair to add that nearly three-quarters (70

per cent) of the cases with an associated empyema present at the time the subphrenic abscess was drained occurred prior to 1924, and that seven of such empyemas were due to neglect with rupture of the subphrenic abscess through the diaphragm rather than as a result of thoracentesis.

TABLE V

INFLUENCE OF ETIOLOGY ON SPACES INVOLVED IN SUBPHRENIC ABSCESS*

Etiologic Factor	Number of Spaces Involved†	Spaces Involved					
		Rt. Post. Sup.	Rt. Ant. Sup	Rt. Inf.	Lt. Sup.	Lt. Ant. Inf.	Retroper.
		Per Cent					
Appendix as original infection.........	54	46	17	20	4	3	10
Stomach and duodenum...........	39	26	36	15	9	14	0
Liver and bile passages............	29	24	48	18	3	7	0
All other causes.....	32	40	16	19	21	0	4

* A total of 154 spaces were involved in the 124 cases. There was but one case recorded as a "subphrenic abscess" involving the left posterior inferior space.

† Twenty-seven cases had abscesses in more than a single space.

In certain instances, all clinical diagnostic measures may fail to clarify in the surgeon's mind which of the subphrenic spaces is involved, and when such is the case, it is important to appreciate the fact that the original cause for the abdominal infection will materially influence the site at which the abscess is most frequently found. (Table v.) Thus when appendiceal peritonitis was the primary pathology, the subdiaphragmatic abscess involved the right posterior superior or right inferior space in two-thirds (66 per cent) of the instances; while with the liver and bile passages as a source, approximately one-half (48 per cent) of the secondary abscesses became established in the right anterior superior space rather than the more dependent but usually drained right inferior space. The central position in the upper abdomen of the antrum of the stomach and duodenum undoubtedly explains not only the approximate uniformity with which the different spaces were involved but also the relative high incidence (23 per cent) of

left-sided abscesses following gastric surgery or the perforation of an ulcer.

The right posterior superior space was the most frequent site of a subphrenic abscess (36 per cent) with the right anterior superior (27 per cent) and right inferior (18 per cent) next in relative importance. (Table VI.) In over one-fifth (22 per cent) of the patients, more than one space contained pus, either because of direct extension from one space to the adjacent one, or because of implantation of infection in more ·than one ¯area at the time of the original spread of sepsis.

TABLE VI
INCIDENCE OF SPACES INVOLVED IN SUBPHRENIC ABSCESS*

Space	Cases	Per Cent
Right posterior superior...............	55	36
Right anterior superior...............	42	27
Right inferior........................	28	18
Left superior........................	15	9
Left anterior inferior................	9	6
Left posterior inferior................	1	1
Retroperitoneal......................	4	3

* A total of 154 spaces were involved in the 124 cases.

The right subphrenic spaces were involved more than five times as frequently (84 per cent) as those on the left (16 per cent), and because of the consistently lower incidence of left-sided involvement found in this series of cases as well as those reported in the literature,[9] there has been a tendency to minimize the importance of abscesses on this side. This tendency is especially unfortunate inasmuch as the anatomic subdivisions of the left subphrenic region are less sharply demarcated and are more difficult to approach without untoward contamination of uninvolved areas than on the right. The fact that the mortality in the twenty-two cases with left-sided lesions in this series (50 per cent) was one and one-half times as great as for those occurring on the right side alone (34 per cent) lends weight to the importance of careful consideration in the treatment of this smaller segregated group.

TREATMENT

In an attempt to satisfy the requisites of ideal treatment by prompt, effective, safe drainage, three general types of operation have been evolved. Each stresses with different emphasis the factors mentioned, and only by comparison of the theoretical advantages and actual results of each can their relative merits be determined.

The transperitoneal type of approach gains access to the infection by traversing the upper portion of the peritoneal cavity and entering directly into the abscess cavity. Although it does not necessitate the delay of a two-stage procedure and usually gives direct and dependent drainage, the contamination of the general abdominal cavity that frequently results is so obviously prejudicial to the successful outcome of the case that no further word of condemnation of this method when it can be avoided is required. It is true that infection in both the left inferior spaces can be drained only by some such type of approach, but it is to be hoped that in such cases adhesions will have formed between the inflammatory area and the anterior abdominal wall that will permit access to the pus without contamination of the uninvolved portion of the peritoneum. In this series, most of the twenty-five cases that were drained transperitoneally were found either in the first half of the study when the advantages of other methods were less fully appreciated (ten cases), or else subsequent to those earlier years in patients with their infection to the left of the midline (seven cases).

The main difference of opinion as to the logical approach in the drainage of a subphrenic abscess centers about whether a transpleural or retroperitoneal type of operation should be adopted. The transpleural operation is carried out by resection of that portion of the ninth, tenth or eleventh rib that is immediately over the lower portion of the suspected abscess. When the underlying pleural cavity has been exposed, it may be safely traversed if it has become obliterated at this point by

an inflammatory reaction and the abscess entered by incising the diaphragm. It cannot be assumed, however, that such obliteration will necessarily take place as a secondary manifestation of the infection of the subdiaphragmatic region; and if doubt exists at the time of operation as to whether the exposed angle of the pleural cavity is obliterated, the transpleural operation should be carried out as a two-stage procedure. The first stage consists of the removal of a portion of the appropriate rib, the suturing of the pleura to the diaphragm about the edges of the wound and the insertion of a pack into the area. At the second stage, two to seven days following the first, the pack is removed, and the further incision into the abscess cavity carried out. Although less than one-third (30 per cent) of the forty-three cases of transpleural drainage of this series were done as a two-stage procedure, there is now general unanimity of opinion that the operation carries a lower mortality when done in two stages than as a single operation. A recognition of this fact has been marked by over a sevenfold increase in the use of the two-stage operation in cases drained by this type of approach during the last twenty years (44 per cent) as compared with the preceding period (6 per cent).

The chief argument advanced for the transpleural type of procedure is that it utilizes the most direct route to the imprisoned pus. It is contended that the interval between the stages, when done as a two-stage operation, is relatively unimportant if the diagnosis has been promptly made; but obviously in many instances the diagnosis has been long deferred and in these it is essential that the pus should be evacuated with the least possible delay once surgery has been adopted.

If the preoperative localization of the abscess has been incorrect, such an approach is ill suited for further exploration; and when a combination of spaces is involved, such an incision cannot drain effectively more than a limited portion of the infection present.

The chief danger in the transpleural approach, however, lies in the possibility, which will be discussed in greater detail later, of inadvertently contaminating an uninvolved pleural cavity and thus initiating an empyema.

The retroperitoneal, or extraserous type of operation, when done for drainage of the commonly involved right posterior or right inferior spaces, is carried out through a skin incision overlying the twelfth rib. It is important that preoperative roentgenograms should be studied to ascertain the length and position of this rib; for if it be a rudimentary structure, as was true in one case in this series, the eleventh may be mistaken for the twelfth rib and thus result in a false orientation by the surgeon in his approach to the region. The twelfth rib is removed subperiosteally in its entirety, and further dissection is then carried out in a horizontal direction at the level of the first lumbar vertebra, rather than along the bed of the resected rib. (Figs. 4 and 5.) The importance of the location of this deeper dissection lies in the fact that, as Melnikoff[10] has shown in a study of cadavers, the pleura on the right extends to below the twelfth rib in nearly two-thirds (62 per cent) of all cases but is never found as low as the level of the first lumbar vertebra, so that a properly placed incision at this lower level will always avoid inadvertent contamination of the pleural cavity. With division of the lower fibers of the diaphragm, the retroperitoneal area above the kidney is entered, and by blunt dissection the peritoneum is readily stripped from the under portion of the diaphragm up to the point where it no longer separates easily because of the inflammatory reaction occasioned by the infection. It is here that the peritoneum is broken through and the abscess cavity entered directly. When either the lateral aspect of the right anterior or the right inferior space is involved, the initial surgical approach is the same but the deeper exploration of the area by blunt dissection is carried out more anteriorly in

the former instance and below the liver edge superior to the kidney in the latter.

If either the right anterior superior or the left superior spaces are involved, an incision is made parallel to and just below the anterior costal margin. (Fig. 6.) This extends down to but not through the peritoneum which is then dissected free from the undersurface of the diaphragm in a manner similar to that already described for the posterior approach. It is important in securing the proper line of cleavage for this dissection that the posterior layer of the rectus sheath and the transversalis fascia directly overlying the peritoneum both be incised lest the separation of the peritoneum from the diaphragm be thwarted by the attachment of these fascial layers.

The advantages of the retroperitoneal type of approach lie in the fact that the operation is a single-stage procedure, thus avoiding any unnecessary delay in evacuating the pus once the diagnosis has been made. Furthermore, entrance into the abscess cavity is effected at its most dependent portion, which is of more fundamental importance in the effectiveness of the resulting drainage than the directness of the route by which the infection is attacked.

The greatest advantage of the retroperitoneal approach, however, lies in the fact that it carries a lower risk of contaminating uninvolved serous cavities than either of the types already discussed. In the fifty-six instances in which the extraserous operation was employed, the pleural cavity was inadvertently exposed to contamination in less than one-tenth (7 per cent) of the cases. When such contamination did occur, it was either because of faulty technic in the removal of the rib from its enveloping periosteum, or in the unfortunate choice of the bed of the rib rather than the level of the first lumbar vertebra as a site for the deeper dissection. This is in contrast to similar encroachment on the pleural cavity in over one-third (35 per cent) of the transpleural operations, regardless of whether

they were done in one or two stages. No instance of contamination of the pleural cavity at the time of operation took place in the transperitoneal type of operation, but this procedure carried a prohibitively high incidence of peritoneal soiling (80 per cent). (Table VII.)

TABLE VII

INCIDENCE OF CONTAMINATION OF UNINVOLVED SEROUS CAVITIES ACCORDING TO TYPE OF OPERATION

Site of Contamination	Trans-peritoneal Per Cent	Trans-pleural Per Cent	Retro-peritoneal Per Cent
Both pleural and peritoneal cavities	0	2	0
Pleural cavity alone	0	35	7
Peritoneal cavity alone	80	0	2
Neither cavity	20	63	91

That this repeated emphasis on the importance of avoiding contamination of an uninvolved serous cavity is of paramount importance is brought out by the fact that the mortality was over two and one-half times as high in cases in which it occurred (63 per cent) as in those in which it was avoided (24 per cent). (Table VIII.)

TABLE VIII

EFFECT OF CONTAMINATION OF UNINVOLVED SEROUS CAVITIES AT TIME OF DRAINAGE OPERATION ON MORTALITY RATE

Site of Contamination	Cases	Mortality Per Cent
Both pleural and peritoneal cavities	1	100
Pleural cavity alone	19	63
Peritoneal cavity alone	21	62
Neither cavity	83	24

The valid objection might be raised that certain factors modify the accuracy of these arbitrary figures concerning contamination of uninvolved serous cavities. One such factor lies in the interpretation of the frequently employed term "contamination," for it was often difficult from the records to

decide whether a serous cavity which had been inadvertently opened and promptly closed had, in fact, been subjected to any contamination by the infectious process the operation primarily sought.

A second source of potential error is found in the tabulation of those nine cases in which more than one type of operation was carried out because of involvement of multiple spaces that could not be approached surgically through a single incision. To permit a relative comparison between the incidence of contamination with each type of operation, every case was classified under a single operative heading which departed from the original surgical approach only if this had been directed toward draining a space that proved subsequently to be of lesser importance than that presented by a second abscess, or if it had been unsuccessful in reaching the abscess cavity. In this latter connection it appears that the medial portion of the right anterior superior and left superior spaces that lie posterior to the convex surface of the liver are probably best approached by the transpleural operation, for in four such cases in which the retroperitoneal operation was adopted, it proved ineffective and was followed by satisfactory drainage from above the diaphragm.

Subsequent to 1917, when an affiliated convalescent home which made possible the early transfer of postoperative patients was discontinued, the average hospital stay for the surviving cases following drainage of a subphrenic abscess by the retroperitoneal route was forty-two days as compared with fifty-seven days for those in which the transpleural operation was adopted. There has been a definite trend in the more recent years of this series with both the retroperitoneal and transpleural type of operation toward a decrease in the stated average periods of hospitalization following drainage, and it is to be hoped that with early diagnosis and adequate surgery, the patient should have sufficiently recovered to permit him to be discharged from the hospital within three weeks following operation.

In comparing the different types of procedures, the rôle of anesthesia has applied uniformly regardless of the operation adopted. There has been in all cases an increasing trend from a general anesthetic to a greater use of local novocaine infiltration for at least the initial stages of each of the operations.

In each of the procedures, two or three cigarette wicks together with the occasional use of a piece of soft rubber tubing were inserted to maintain adequate drainage until the process had completely subsided.

There has been too small a number of cases (four) to draw any conclusions as to the efficacy of chemotherapy as an adjunct to surgery, but experience in dealing with the somewhat analogous situation found in appendiceal abscesses would lead one to suppose that the use of the sulphonamides might play an important part in the future in lowering the mortality of cases with collections of pus in the subphrenic region.

MORTALITY RATE

It is difficult to evaluate the relative merits of the different procedures in terms of their respective mortality rates, for in many instances the fatality was due primarily to the original pathology and death would probably have ensued even if no subphrenic abscess had developed. To segregate such patients, however, in an attempt to arrive at a corrected mortality rate would introduce too great an element of fallible evaluation to make the resulting figures reliable. In certain additional cases, complications other than those already discussed as having a peculiarly close relationship to the subphrenic abscess have played an important part in the ultimate outcome of the case, but here again a weighting of the figures would seem to be more misleading than corrective. For these reasons, all deaths in this series are included in computing the mortality rates of the different types of drainage of subphrenic abscesses, as it was believed that in a series of cases of this size, these ex-

traneous factors would tend to occur so relatively uniformly within the three groups that they would exert a comparable effect on each. Certainly it is true that in almost all the fatalities the presence of a subphrenic abscess in an already depleted patient was the deciding factor in the untoward outcome of the case.

Ochsner[1] has shown that the mortality rate can be reduced to below 20 per cent, and the figure of 24 per cent for the two-thirds (67 per cent) of the cases in this series in which no contamination of a serous cavity took place is further evidence that regardless of other considerations, with proper surgical treatment, not over one out of four patients who develop a subphrenic abscess should die. The mortality of 37.1 per cent for this entire series is unduly high because of the difficulties in diagnosis and surgical management of these patients in the period from 1900 to 1920, and the unfortunate number of instances in which contamination of uninvolved areas has continued to take place since that time.

A growing conviction borne out by available statistics that in all save exceptional instances the retroperitoneal type of approach provides the safest method of draining a subphrenic abscess has led to an almost unbroken increase in the frequency with which this method has been employed in these cases. (Chart 1). The conclusion that the consistent improvement in the mortality rate can be attributed solely to this factor is, of course, unjustified, for the better understanding of postoperative care during more recent years might be cited as but one of a number of additional factors that have tended to decrease the death rate. The fact remains, however, that the greater avoidance of a spread of infection with the extraserous approach is the chief reason for the smaller proportion of fatalities during the more recent years.

Even at the hospital from which these figures and beliefs have emanated, there still exists some difference of opinion as to

the wisdom of accepting the retroperitoneal type of approach in all cases in which it might be employed. During the past six
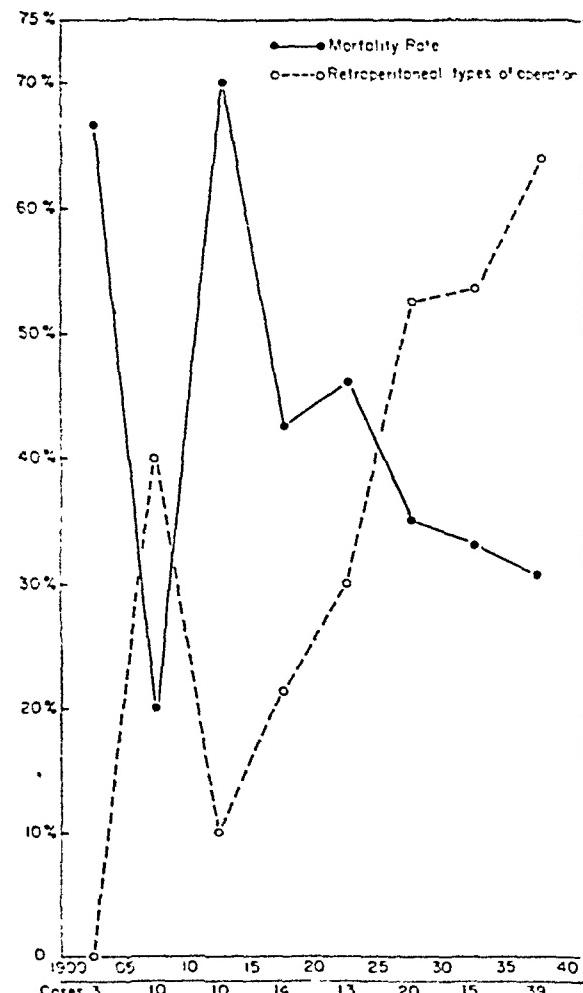
CHART 1. Showing the increasing incidence in the use of the retroperitoneal type of operation and the decreasing mortality rate over the period studied.

years, there were over one-third (35 per cent) of the cases of this series that were treated by some other form of operation, and it remains to be seen whether with further time and added evidence the extraserous procedure will completely supplant the transpleural and transperitoneal types of drainage in all save the small groups of cases already referred to for which it does not seem applicable.

SUMMARY AND CONCLUSION

The statistical data compiled from 124 consecutive cases of subphrenic abscess operated upon at the Massachusetts General Hospital from 1900 to 1941 are pre-

sented to illustrate the salient features of diagnosis and treatment of this condition. From these data the following conclusions can be drawn:

1. At least one-fifth of all cases with "subphrenic inflammation" subsided without suppuration.

2. Surgical drainage is indicated as the accepted treatment for a subphrenic abscess.

3. A thorough knowledge of the location and anatomic boundaries of the six spaces into which the subdiaphragmatic area is divided is essential for prompt diagnosis and early intelligently planned surgical drainage of a subphrenic abscess.

4. Inadvertent contamination of an uninvolved serous cavity during the drainage of a subphrenic abscess more than doubles the mortality rate.

5. The retroperitoneal type of approach may be effectively employed in the drainage of over four-fifths of all subphrenic abscesses. It is the logical surgical approach to most cases of subphrenic abscess as it is attended with the lowest incidence of contamination of uninvolved serous cavities and carries with it a lower mortality rate than the other two types of operation.

6. Although the posteromedial portions of both the right anterior superior and left superior spaces can be reached by the retroperitoneal type of approach, the transpleural type of operation would seem more desirable in the drainage of these areas.

7. The transperitoneal type of operation, due to anatomic considerations, is the only one available for the drainage of the left inferior spaces. It should not be employed as a surgical approach to any of the other spaces.

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TUMORS OF THE THORACIC CAGE

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TUMORS of the chest wall may be divided into two broad groups: those affecting the soft tissues (exclusive of tumors of the breast) and those arising from the bony and cartilaginous framework. The former include all those affecting similar tissues elsewhere; the latter those affecting other bony and cartilaginous structures. In addition it should be remembered that growths originating within the chest may give rise occasionally to outward swellings either by extension into the wall or by expanding the wall in the region of the growth. A young woman who came under my care some years ago with what proved to be a lymphosarcoma of the mediastinum had an obvious bulging of the sternum which receded with radiotherapy, without any actual invasion of the tissues of the wall. In addition to these primary neoplasms it is necessary to consider in differential diagnosis the metastatic lesions which so frequently involve the ribs and sternum, as well as inflammatory swellings which may simulate new growths.

Soft Tissues. The various tumors of the skin found elsewhere occur on the chest. They include papillomas, occasional basal cell and epidermoid carcinomas, benign and malignant melanomas. The problems of diagnosis and treatment present no unusual features and need not be considered here.

Lipomas occur fairly frequently and in general resemble other fatty tumors. The need for removal of these will depend chiefly upon their location and size but occasionally, in the case of neurolipomas, upon pain and tenderness. They sometimes attain a great size. A lipoma arising deeply in the intercostal space may take on a dumbbell or collar button form, part of the growth lying superficial and part deep to the ribs. It is obvious that removal of such tumors presents a special problem. Fibromas and fibrosarcomas occur rather infrequently. If the lesion is really a fibroma a very simple local removal is, of course, all that is necessary. The borderline type of growth in which there may be difficulty in arriving at a certain diagnosis of benignancy or malignancy may present a real problem as illustrated by the following two case histories:

1. Miss V. Z. No. 093799, was admitted to the hospital on September 17, 1934 with the history that fifteen months previously she had noticed a lump on the right chest near the inner border of the breast at about the level of the sixth costal cartilage. Five months later when it had attained the size of a lemon it had been removed locally. The pathological diagnosis was fibrosarcoma. Three months after this operation another lump was noticed at a slightly higher level. This had increased slowly in size. On examination there was a mass three inches long extending laterally from the sternum along the cartilage of the fourth rib and extending over the cartilage of the fifth rib. It was definitely attached to if not actually arising from cartilage. X-rays were negative. On October 6, 1934 a wide resection of the mass along with the cartilages of the fourth, fifth and sixth ribs and an attached block of soft tissues was carried out, the chest cavity being widely opened in the process. The patient made a good recovery. The specimen was composed of a dense mass of fibroblastic tissue arranged in whorls and infiltrating the adjacent soft tissue and cartilage. There were occasional mitotic figures. It was regarded as a low-grade fibrosarcoma. Radium packs were applied when healing was complete. On April 6, 1937 she was re-admitted with a hard, oval mass three and one-half by one inch apparently fixed to the cartilage of the third rib. On April 9, 1937 a wide resection of this mass and the cartilages of the second and third ribs was done. The pathological picture was the same as that

of the mass removed previously. There was no further evidence of recurrence until November, 1939, at which time the patient was lost track of.

2. Mr. Wm. R., No. 091437, age forty-six, was admitted on July 11, 1934 with the history that for eight years he had had a growth on the chest wall. Three years previously it had been removed. One and one-half years later it had begun to recur in the scar and had increased slowly to the size of a walnut. Examination revealed a linear scar four inches long, one inch below the left clavicle and parallel with it. In the center of this scar was a mass the size of a walnut. It was hard, nodular and freely movable on the deep structures. There was no enlargement of lymphnodes. A fairly wide local removal was done including a portion of the fascia of the pectoralis major. Microscopically, the growth was a borderline type but was regarded as a low-grade fibrosarcoma. The patient was readmitted in June, 1936, and stated that six months after the last operation a recurrence had appeared again in the scar and had slowly increased in size. It was once more the size of a walnut. This time a very wide removal of skin and underlying pectoralis major muscle was done. The pathological picture was similar to the original and again gave the impression of very low-grade malignancy. Two courses of H. V. therapy were administered to the chest wall after the wound had healed. In October, 1940, there had been no recurrence.

These cases illustrate the tendency of this type of growth to recur after anything but the most complete extirpation. They are not radiosensitive and must be treated surgically. The cellular, more rapidly growing type of fibrosarcoma is more likely to respond to radiation.

Tumors of blood and lymph vessels of the chest wall apart from ordinary nevi would seem to be very rare. They present the usual features and if not too extensive should be removed. An infant that came under our care some years ago had an enormous hemolymphangiolipoma involving most of the chest wall and abdomen. It was present at birth and grew at least as rapidly as the child. An exploration done in the hope of removing it piece-meal showed that it invaded the underlying muscles and that removal was quite impossible. It was benign and the child was quite healthy although greatly deformed by the growth, presenting the appearance of being bloated.

Ribs and Cartilages. Primary tumors of ribs and cartilages are distinctly uncommon. They comprise all those tumors of bone and cartilage that occur elsewhere and in general present the same characteristics and tendencies.

Chondromas and osteochondromas would seem to be the commonest of the benign lesions. They may occur anywhere in the course of the rib but are more frequent over the anterior chest wall in the neighborhood of the costochondral junctions. The swelling produced is usually more or less fusiform in shape and painless unless pain be produced by pressure on adjacent structures. They are hard, somewhat nodular and not tender. They are likely to be discovered accidentally and are, therefore, of uncertain duration. The x-ray appearance presented depends upon whether they are composed exclusively of cartilage, of cartilage with calcification or of cartilage and bone. The pure cartilage growth may not be recognizable in the x-ray; the chondroma with calcification tends to throw a dense shadow of a somewhat flocculated character; the one in which bone has been formed gives a shadow of varying density but of more regular arrangement than the calcifying chondroma. These tumors are stated to have a tendency to undergo malignant changes but it is difficult to know how often this occurs. One seen recently had been present for twenty years with little change and was quite benign. On the other hand one seen just previously had been present for many years without any apparent change but had then commenced to grow rapidly and when seen was an enormous chondrosarcoma. However frequent this tendency may be these tumors should be removed when encountered. Because incomplete removal is likely to

be followed by recurrence, even in the case of benign growths, they should be removed along with the enclosing periosteum, attached muscles and underlying pleura, unless the latter strips away very readily, since an attempt to save an adherent pleura is likely to result in the leaving behind of tumor cells. They are not radiosensitive and radiotherapy has no place in their treatment.

Giant cell tumors of ribs are very uncommon. Only eleven cases have been reported. They may occur anywhere in the course of the rib and give rise to the well known expansile lesion. Attention is attracted to them by pain and not infrequently by pain that results from a pathological fracture. If the tumor is palpable it is likely to be elastic or may be elastic with the sensation of a yielding shell. The x-ray appearances are such that one cannot distinguish these from other expansile lesions. Single myelomas and single metastatic deposits have to be considered particularly in the differential diagnosis. A successful aspiration biopsy often can be obtained. Giant cell tumors may be treated by radiation, if one can be certain of their character, with some success. On the other hand, they are readily and certainly cured by excision and this would seem to be the method of choice. The excision should include a sufficient portion of healthy rib on either side along with the attached muscle, periosteum and the underlying pleura unless the latter be quite free from the tumor.

The ribs are often the site of lesions of multiple myeloma. Two single myelomas of ribs have come under our care. The x-ray appearance was similar to the well known picture of the multiple form. If thorough x-ray studies of the remainder of the skeleton fail to show another lesion, removal of the apparently single lesion is justifiable in the faint hope that no other focus exists. Negative x-rays and indeed negative autopsy findings in such patients do not exclude with certainty other minute

foci. In the presence of single or multiple myelomas, the Bence-Jones test for proteinuria may and may not be positive. A negative test is therefore of no value but a positive result is very useful. One of our patients died of pneumonia following operation; the other remained well for eighteen months at which time other lesions appeared. She died nine months later of myeloma.

Metastatic Lesions. The ribs are involved by metastases much more frequently than by primary growths. The commonest source of these metastases is cancer of the breast but any carcinoma giving rise to blood-stream metastases may be responsible. Since these secondary lesions may make themselves evident long before any symptoms are produced by the primary lesions, the recognition of their character is important. They may give rise to local pain or soreness or to pain that is referred along the course of one or more intercostal nerves or in the case of involvement of the upper ribs to brachial plexus pain. On the other hand, extensive metastatic involvement of ribs may be present without any directly related symptoms.

If the x-rays show multiple areas of involvement, the condition is likely to be confused only with multiple myeloma. I have, however, seen extensive mottling of the ribs in cases of general debility of unknown origin that resembled very closely the appearance sometimes produced by multiple metastases from breast cancer.

The single lesions may be confused with giant cell tumors or single lesions of multiple myeloma. We have seen single metastases of ribs in a few small and apparently easily operable cancers of the bronchus.

When ordinary methods of clinical examination have failed to disclose a primary cancer from which metastases might have arisen and the diagnosis therefore remains in doubt, aspiration biopsy will often be conclusive. The destruction of the cortex of the ribs has

been sufficient usually to make this procedure a simple one. It may not be possible from the small bit of tissue removed to be certain of the nature of a primary lesion, but it will be possible usually to recognize that it is a secondary cancer and thus save the patient from an unnecessary operation.

When these metastatic lesions are producing pain, the use of deep x-ray therapy is worthy of trial. In those arising from cancer of the breast relief of pain is the rule. Those arising from cancer of the bronchus are less certain to respond. Metastases from malignant adenoma of the thyroid apparently vary in their response, some failing to respond at all. On the other hand, I have seen an enormous metastatic tumor of rib from a primary cancer in an adenoma of the thyroid disappear completely and the patient has now been well for several years.

Ewing's Tumors. Ewing's tumor of ribs, if one may judge from the number of cases reported, is a rare disease. Only eight cases in which the diagnosis was certain have been reported. One further case was reported by me in which the diagnosis was not confirmed histologically. The patient developed metastases since that report and died but an autopsy unfortunately was not obtained. The ultimate outlook in all Ewing's tumors, regardless of the location, is bad. The best hope would seem to be early radical removal. Palliation only may be expected from radiotherapy.

Chondrosarcoma. Chondrosarcomas may be divided into two groups: those that are primarily malignant and arise in the absence of a pre-existing benign growth and those that represent late malignant changes in a benign chondroma. If one may judge from the few cases in this series, the primary malignancy is more common. One has the impression that the pathologist's opinion as to the benign or malignant character of these tumors, if based on the histological picture alone, is

unreliable. There are, of course, those tumors in which the picture presented is so definitely one of malignancy that no possible doubt need be entertained but there are many others in which the clinical course, x-ray appearance and histological characters must all be taken into account if a reasonably accurate opinion is to be formed. From the clinical aspect, the strongest suggestion of malignancy comes from a rapid increase in size. The simple chondromas have usually shown no definite increase in size from the time that they were discovered accidentally and may have been known to exist for a very long period without appreciable change. In the small series that has come under my observation there have been three quite different x-ray appearances: (1) a circumscribed shadow barely visible on the x-ray films, (2) a circumscribed dense shadow of more or less flocculent character and (3) an extensive destruction of rib such as might be found in any destructive malignant growth. The first two differ in no way, as far as I can determine, from the picture of benign cartilage growths; the third leaves no doubt as to the malignant nature of the lesion.

Early radical excision of chondrosarcomas of a circumscribed character should offer a reasonable prognosis. They must be removed along with adjacent muscles and usually, if not always, the underlying pleura. In the rapidly growing ones such as Case XIV, no form of treatment offers any hope. Radiation is not effective and its use before surgical intervention merely renders the surgical procedure more difficult and more hazardous because of the likelihood of the wound breaking down if it has been made through intensively radiated tissues.

Osteogenic Sarcoma. Osteogenic sarcoma of ribs has been reported very rarely and only one occurred in this series. The reported cases suggest that the condition shows a predilection for the posterior portions of the ribs. The patient's attention may be directed to the growth

by the accidental discovery of a swelling or by pain. The x-ray appearance is that of a destructive lesion with varying amounts of new bone formation. The picture presented by those showing considerable amounts of new bone formation differs somewhat, I think, from that of the calcifying chondroma or chondrosarcoma, although they probably cannot be differentiated with certainty either from these or some metastatic lesions of the ribs. Final diagnosis must be made always by biopsy.

In the absence of definite deterioration of general health and evidence of metastases these lesions should be treated by radical surgical removal. Treatment with radiation either as a therapeutic test, in the absence of a definite diagnosis, or in the hope of control when a diagnosis has been established by biopsy, is not in my opinion justifiable if the condition appears to be still localized and capable of surgical removal.

CASE REPORTS

CASE I. *Giant Cell Tumor.* A man, forty-nine years old, had complained of pain along the right costal margin for ten months. Clinical examination of the chest was negative, but the screen revealed a tumor of the seventh rib in the postaxillary line. There was no deterioration in general health. X-ray examination showed a fusiform enlargement and area of destruction of the seventh rib about three inches in length. The hemoglobin was 83 per cent, white blood count 10,800, and Bence-Jones protein test, negative. At operation September 19, 1936, the seventh rib, along with the adjacent intercostal muscles and underlying pleura, were removed from the vertebra to the anterior axillary line. Recovery was uneventful. In the gross the specimen consisted of a soft grayish-red mass, expanding and largely destroying the rib over an area 8.5 cm. long. The cut surface was vascular and dark red brown. The central part appeared to be broken down and was enclosed by a shell of a maximum thickness of 2 mm., the outer part of which consisted of periosteum with a very thin incomplete layer of bone beneath it. Microscopically, the wall of the cystic space

was seen to be formed in large part by fibroblastic tissue, which suggested an inflammatory lesion. Other areas presented what seemed to be definite evidence of tumor formation with here and there a few giant cells. Under the thickened periosteum was a thin layer of new bone. A diagnosis of giant cell tumor was made. (Fig. 1.)

The patient died in February, 1939, and though no autopsy could be obtained it was presumed that the cause of death was bronchogenic carcinoma.

CASE II. *Myeloma.* A woman, sixty-three years old, had consulted her physician frequently during the previous six to seven years because of pain in the region of the right shoulder. It was considered, apparently without any real evidence, to be due to a mild pleurisy. In the past year she had had a persistent, nonproductive cough and, for six months, had noted an increasing pallor. X-ray examination of the chest, made six weeks before admission, showed an expansile tumor of the second rib just lateral to the cartilage but with no change in the underlying lung or pleura. Clinically, she was well nourished, somewhat pale, but presented no abnormality apart from a marked sclerosis of the peripheral vessels and a slight thickening below the left clavicle. This swelling appeared to pulsate. X-ray films of most of the remainder of the skeleton showed no other areas of destruction. No other primary tumor from which a metastatis might have arisen could be found. The hemoglobin was 75 per cent, white blood count, 5,200 and the differential smear was not abnormal. The Bence-Jones protein test was negative. At operation on June 17, 1930, the soft tissues of the anterior chest wall were turned upward and mesially from an axillary incision. The tumor and the adjoining rib and cartilage, the attached intercostal muscles, and the underlying pleura were removed en masse. The growth extended from the middle of the second costal cartilage to midaxilla, following the line of the second rib. (Fig. 2.) Recovery was uneventful.

The gross specimen consisted of a fusiform mass 8 by 4.5 by 2 cm. It was soft, dark red, and appeared to be a mass of hemorrhagic material enclosed by a fibrous capsule. Microscopic examination disclosed a very cellular tumor, the cells of which varied greatly in size and shape, some being small and round, others

long and spheroidal. Many of the smaller cells possessed dark-staining eccentric nuclei and were somewhat similar to plasma cells. The

soft tissue. At operation, January 15, 1932, the adjacent portions of the fifth and seventh ribs were first resected and the tumor then re-
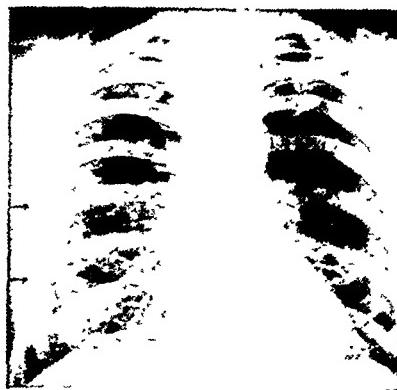
FIG. 1. Case I. A giant cell tumor of the seventh rib.
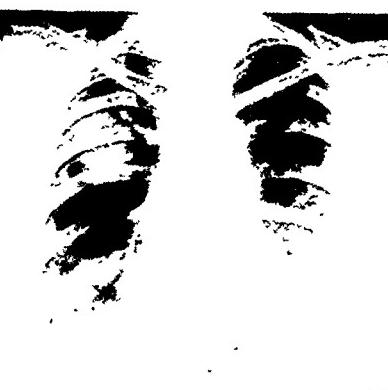
FIG. 2. Case II. A single myeloma of the second rib.

larger cells presented considerable variation in the amount and distribution of nuclear content. It was regarded as a single myeloma.

The patient remained quite well until December, 1931, (eighteen months) when an aching pain developed in the left jaw and, shortly afterward, swelling. In January, 1932, she noticed pain above the right knee. X-ray films made in February, 1932, showed the typical expansile lesion of myeloma in both these bones. A spontaneous fracture of the femur occurred. She died nine months later. Unfortunately the Bence-Jones test was not repeated.

CASE III. *Myeloma.* A man, sixty-one years old, had had a fracture of the eighth rib on the right side three years previously. X-ray pictures made at that time showed a fracture of the eighth rib and a normal sixth rib. There had been pain in that region from time to time since the injury, and he had been treated by adhesive strapping. For six months the pain had been more severe, and one week before admission he had noticed a lump. Examination revealed a mass about 5 by 9 cm. along the sixth rib in the right axilla. It was elastic to touch, and there was an impulse on coughing. X-ray examination showed no other bony abnormality. The Bence-Jones test was not done. X-ray of the chest showed an area of destruction of the sixth rib, beginning about 2 cm. lateral to the costochondral junction and extending along the rib for about 9 cm. The appearance presented was thought to be that of an expansile tumor which had ruptured through the cortex and now lay partly in the

moved along with the whole of the intercostal bundle on either side and the underlying pleura. The diaphragm was used to close the defect. He died of pneumonia on the third postoperative day. No autopsy was obtained.

CASE IV. *Chondroma.* A man, thirty years old, was found to have a tumor of the right chest wall in the course of routine examinations of the chests of a group of factory employees. There were no associated symptoms. The right upper chest was definitely flat, and the retraction involved especially the third rib and cartilage. There was a hard, slightly irregular, fusiform swelling of this rib just beneath the axillary border of the pectoralis major. X-ray examination revealed a tumor of the third rib about three inches in diameter which extended laterally from the costochondral junction. (Fig. 3.) It had an irregular mottled appearance. At operation November 2, 1938, an incision was made along the pectoral border and extended medially toward the sternum. The pectoralis major was divided below and reflected upward and inward. The tumor with about one inch of rib lateral to it, a similar length of cartilage medial to it, a small portion of attached muscles, and the underlying pleura were removed. There was only one small band-like adhesion to the underlying visceral pleura, despite the fact that the mass had formed a definite depression in the lung. The second and fourth ribs and cartilages were separated more than usual because of the tumor, and it seemed that a considerable defect in the chest wall would result unless some sort of plastic repair could be accomplished. The fourth rib

and cartilage were split with a motor saw from near the sternum to beyond the point of division of the third rib laterally, leaving the remaining portions of intercostal muscles and periosteum attached to it. The upper half was divided medially, carried up and fastened with a single chromic catgut suture into a seat prepared by removing, subperichondrially, the small remaining portion of the cartilage of the third rib. In doing this, a greenstick fracture was produced at the outer end. The fascia and a thin sheet of muscle were dissected from the pectoralis major muscle and carried beneath the graft to provide a smooth surface between it and the underlying lung. The remaining portion of the pectoralis major was sutured securely into position with chromic catgut, and finally, the subcutaneous tissues and skin were closed. Convalescence was somewhat stormy because of the occurrence of a massive pleural effusion and pulmonary collapse. The patient is now well and has a chest wall of normal stability.

In the gross the tumor was a hard mass of bone and cartilage 11.8 by 7 by 5 cm. Microscopically, it was seen to be made up of large islands of cartilage cells lying in clear spaces surrounded by blue-staining matrix. Many areas had undergone calcification, but true bone formation was not seen. Cyst-like spaces lined by cartilage cells were distributed irregularly throughout the tumor. The surface was covered by a layer of dense fibrous connective tissue. It was regarded as chondroma with calcareous degeneration.

CASE V. *Osteochondroma.* A man, forty years of age, had complained of a continuous dull ache or pain in the left chest since the spring of 1916. A lump was noticed in the summer of 1917 over the lower left chest. It had enlarged slowly. There was a rounded swelling extending posteriorly from the costochondral junction of the ninth and tenth ribs and projecting about one inch from the level of the chest wall. X-ray examination showed a bony tumor, markedly irregular in outline and appearing to encroach upon the abdominal cavity through the diaphragm. At operation on August 16, 1918, the growth was found to be arising from the ninth rib in the region of the costochondral junction. It was removed along with the neighboring portions of rib and cartilage and the adjacent soft tissue and pleura. The diaphragm was found to have been

displaced but not perforated. Recovery was uneventful. In the gross, the specimen consisted of a mass of cartilage and bone the size of an
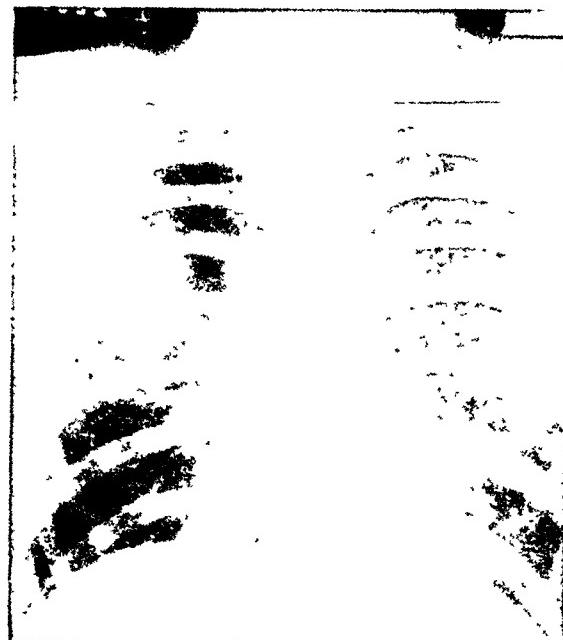
FIG. 3. Case IV. A chondroma of the third rib.

orange. Histologically, it was a benign osteochondroma. The patient is still alive and well.

CASE VI. *Osteochondroma.* At the age of twelve to thirteen years the patient had a definite injury to her right chest wall. Some time later a lump was noticed in the region of the injury and three to four years after this the lump was removed. It proved to be an osteochondroma. The lump recurred and in 1921, at the age of twenty-four years, she presented herself with an elastic, nodular tumor the size of half an orange, fixed to the right anterior chest wall near the sternum. There were no associated symptoms. On November 27, 1929 the recurrent tumor was removed, this time along with the adjacent portions of the chest wall and the margin of the sternum. It was again an osteochondroma composed almost entirely of cartilage. There has been no recurrence.

This case illustrates the tendency of these tumors to recur following incomplete removal.

CASE VII. *Osteochondroma.* A man, fifty-one years of age, first noticed a swelling in the region of the inner end of the left first rib about six months previously. He had taken a plaster mould of it and had satisfied himself that it had enlarged during the past few months. Movement of the arm produced some soreness

in the region of the swelling and a pain which was referred to the shoulder area. Examination revealed a hard mass apparently bony, involv-

FIG. 4. Case VII. Illustrating the anatomical relation of the tumor.

the way. The great veins were dissected out, the phrenic nerve retracted and the attachment of the scalenus anticus divided. The subclavian
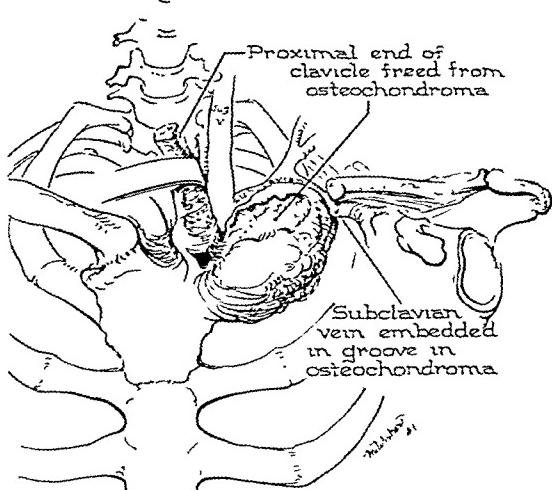
FIG. 5. Case VII. Showing the manner in which the exposure was obtained and the mass freed from the surrounding structures.

ing the inner end of the left first rib and cartilage, extending to the sternum and either involving or incorporating the inner end of the clavicle so that it was impossible to be certain whether or not the clavicle could be moved apart from it. X-ray showed what appeared to be a bony tumor apparently originating in the region of the costochondral junction of the first rib. There was no apparent involvement of clavicle or sternum.

Operation demonstrated the fact that removal of a tumor from this particular region involved some special hazards and dangers. A wide U of skin and subcutaneous tissue was turned from the chest wall well upon the base of the neck. The pectoralis major and platysma muscles were divided from the clavicle, leaving sufficient muscle attached that they might be sutured back into position. The clavicle was now divided with a Gigli saw at about its middle so that the inner end might be turned up out of the way. (Figs. 4 and 5.) It was found that the clavicle was either so intimately adherent to the growth or actually involved by it that it seemed unsafe in case the tumor should prove to be malignant, to separate the two. The lower third of the clavicle was therefore chiselled off with an osteotome and left attached to the tumor. The remaining two-thirds being now free was easily turned upward and inward out of

vein was embedded in a U-shaped groove in the tumor and intimately adherent, its lumen being reduced by one-half at this point. It was dissected free with great difficulty. The pleura stripped readily from the inner aspect and remained intact. (Fig. 6.) No line of differentiation could be made out between the mass and sternum and a V-shaped piece of sternum was therefore removed with the mass, the first rib being divided three-fourths inch distal to the tumor. The divided clavicle was re-united by a Kirschner wire in its lumen and a stainless steel wire suture to maintain apposition passed through drill holes made before the division. The muscles were re-united to the clavicle and the wound closed. (Fig. 7.) Recovery was uneventful. The tumor proved to be a benign osteochondroma composed of dense bone with irregular extensive cartilage formation throughout.

CASE VIII. *Chondroma*. A woman, sixty-four years old, was seen December 8, 1936. Since girlhood she had had a hard swelling of small size on the left chest above the breast. Three years ago this lump had begun to increase in size and recently had been enlarging quite rapidly. It was not painful or tender. Examination revealed a nodular tumor the size of an orange, attached to the left anterior chest wall in the neighborhood of the costochondral junction of the first and second ribs. X-ray

revealed a calcifying tumor arising from the first rib in the region of the costochondral junction. It was removed along with the

Fig. 6. Case vii. Same as Figure 5.

adjacent rib and cartilage on December 21, 1936.

The specimen consisted of a nodular tumor 11 by 8.5 by 8 cm. The cut surface was grey in color, smooth and apparently cartilaginous. There was a central area of degeneration and hemorrhage. Microscopic examination showed that the mass was composed of cartilage cells and fibrous tissue with areas of hemorrhage and calcification. It was regarded as a benign chondroma. There has been no recurrence.

CASE IX. *Chondroma.* A woman, sixty-five years of age, was seen July 18, 1939. She had had a swelling over the right anterior chest wall for thirty years. It had slowly increased in size during ten years and during the past five years had grown very fast. Six weeks previously a mild injury had resulted in ulceration. The patient died on July 23, 1939, apparently as a result of infection and debility. The tumor was removed at autopsy. (Fig. 8.) It was 20 by 17 by 14 cm. and on cut section appeared to be cartilaginous with numerous cystic spaces and areas of degeneration and hemorrhage. Microscopically, it was composed for the most part, of mature cartilage in which were areas of fibrous and myxomatous tissue. There was considerable old hemorrhage with dense infiltration of acute and chronic inflammatory cells. The final diagnosis was chondroma with myxomatous degeneration, hemorrhage and infection.

CASE X. *Chondrosarcoma?* A man, aged forty-five years, was admitted in August, 1940. He had noticed a swelling over the right
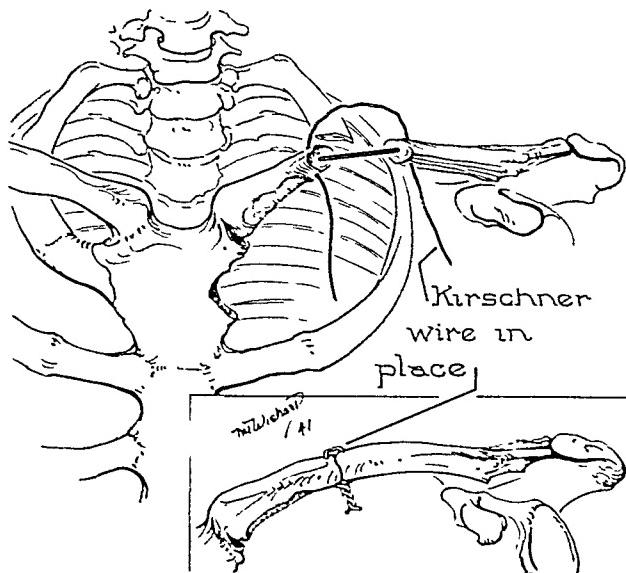
Fig. 7. Case vii. The reconstruction of the clavicle.

anterior chest wall fifteen years before. It had increased in size gradually over the years but was thought to have grown more rapidly during the past two years. It had produced no symptoms. Examination revealed a somewhat irregular tumor the size of a lemon attached in the region of the costochondral junction of the ninth and tenth ribs. In the x-ray the tumor cast a barely visible shadow. Since the patient was really in the hospital for treatment of a very toxic goiter and had been operated upon recently for this, the tumor was removed under local anesthesia on September 16, 1941, no attempt being made by the surgeon to do a wide removal.

The specimen consisted of a hard nodular tumor 8.5 by 7 by 5 cm. The cut surface was greyish in color, smooth and glistening. There was a good deal of calcium. Microscopically, it was made up of atypical cartilage cells that tended to be arranged in groups with a good deal of cartilage matrix between them. There was considerable evidence of necrosis and hemorrhage. It was regarded by the pathologist as a chondrosarcoma but from a clinical point of view was thought to be more probably benign. There has been no recurrence to date.

CASE XI. *Chondrosarcoma.* A man, sixty years of age, was seen on April 3, 1940. A growth was noticed on the right chest wall in August, 1938. There was no pain. The growth increased in size gradually. A biopsy

done elsewhere in October, 1939, was reported as malignant. Examination revealed a tumor the size of a grapefruit involving the ninth,

diagnosis of osteogenic sarcoma and gave an intense course of deep x-ray therapy. Apart from the production of very severe x-ray

FIG. 8. Case IX. An enormous tumor of some thirty years' standing which although apparently benign finally resulted in death from infection that followed ulceration.

tenth and eleventh right ribs in the costochondral region X-ray showed that it was densely calcified. The mass along with the adjacent portions of the chest and abdominal wall was removed on April 9, 1940. The pleura and peritoneum were stripped from the tumor quite readily. Closure of the defect was imperfect. The specimen measured 13 by 12 by 8 cm. with attached portion of three ribs and soft tissues. On cut section it showed hemorrhage, necrosis and irregular areas of calcification. The middle of the three ribs was destroyed entirely over a length of three inches. Microscopic examination showed that the tumor possessed a dense, fibrous capsule freely supplied with blood vessels. Running inward from the capsule were fibrous septa between which were atypical cartilage cells. The central portion showed marked myxomatous changes. Diagnosis was chondrosarcoma. At present the patient is well apart from the presence of a hernia for which a belt must be worn. There is no evidence of local or general recurrence.

CASE XII. *Chondrosarcoma.* A man, aged thirty-nine years, was admitted October 27, 1940, with a history of pain and swelling over the left upper chest posteriorly for two years. He attributed these changes to a fall suffered two years before but since the swelling was much the same size at that time as on admission it was believed that the blow merely attracted attention to the condition. One year later he had consulted a radiologist who made a

changes in the skin and deeper tissues of the chest wall this treatment had resulted apparently in no change. His general health was good. Examination revealed a swelling about four by six inches attached to the ribs of the upper chest wall medial to the scapula and overlapping the scapula and vertebral spines but not attached to them. There were intense radiation changes in the skin although no radiation had been given for six months. X-ray showed an irregular calcifying mass arising from the fourth rib in the region of the angle and lateral to it and largely destroying the contour of the rib over an area of about three inches. The neighboring ribs seemed merely to be involved in the extension of the tumor. On November 1, 1940, the tumor mass along with the posterior portion of the upper seven ribs, attached soft tissue and underlying pleura were removed en masse. The fourth rib was disarticulated, the others removed to the transverse process only. By using the scapula a fairly satisfactory closure was obtained The radiated tissues subsequently broke down, the patient developed an empyema and had a stormy postoperative course but is now well.

The specimen consisted of a hard tumor mass 14 by 11 by 6 cm. with attached ribs. Histologically, it was made up of cartilage cells showing great variation in size and staining. The stroma varied from a hyaline to a fibrous type. There were irregular areas of myxomatous degeneration and calcification

throughout the tumor. Diagnosis was chondrosarcoma with calcification.

Case XIII. *Chondrosarcoma*. A man, sixty-three years old, noticed a swelling of the left chest wall in October, 1937. The mass was not painful and was noticed by chance. X-ray films made shortly after showed a tumor about 10 by 12 cm., arising from the region of the costochondral junction of the third rib on the left side. The shadow was very indistinct because of an almost complete absence of calcium. Examination revealed a flat, firm swelling about two inches in diameter arising from the third left rib lateral to the costochondral junction. What appeared to be the whole growth was removed by his surgeon on November 16, 1937.

The specimen consisted of a mass 7 by 6 by 5 cm., which appeared to surround the rib. It was moderately firm, pinkish and somewhat lobulated. On section it was gelatinous in appearance and very friable. Microscopically, the tumor was seen to be made up of large masses of cartilage cells. Near the periphery it was very cellular, and the cells were less differentiated in character and were invading between the fibers of attached muscle. There were a few areas of myxomatous degeneration.

The patient received one series of 3,000 R. postoperative radiation but failed to report for further treatment. He returned November 3, 1938, with numerous secondary masses in the region of the incision. Subsequent radiation failed to control these recurrences and he died of the disease.

Case XIV. Chondrosarcoma. A sixteen year old Jewish boy was admitted to the hospital on February 4, 1941, with a three-day history of dry cough, left-sided pleural pain and shortness of breath. Three months previously his chest had been x-rayed, because his tuberculin test was found positive in a routine survey and the report was negative. Examination revealed a well nourished boy with a thoracic scoliosis with convexity to the right. There was a peculiar prominence of the ninth and tenth ribs on the left side posteriorly which he said had been present all his life. There was a left pleural effusion which on aspiration proved at first to be clear fluid and later to be blood tinged. The fluid was sterile and no tumor cells could be found in it. There was a low-grade fever and a leucocytosis of 16,200. X-rays showed a destructive lesion with some calcium deposition in the ninth rib on the left side beginning

medial to the angle and extending for a distance of three inches laterally. A biopsy was taken. This showed a lesion made up of atypical cartilage cells growing in a haphazard fashion with numerous mitotic figures. There was no bone formation.

The patient's course was down hill rapidly and he died on March 13, 1941.

Case XV. *Osteogenic Sarcoma*. A man, fifty-four years of age, was admitted July 21, 1938. One week previously his son had noticed a deformity of the lower chest. There were no local symptoms, and the general health had remained good. There was an elongated swelling of the eleventh right rib which extended forward for about seven inches from a point near the spine and was of a maximum width of about two and one-half inches. It was firm, somewhat irregular in outline and not tender. X-ray examination showed replacement of the eleventh rib by a circumscribed tumor which had a vacuolated appearance suggestive of either a chondroma or chondrosarcoma. At operation, July 22, 1938, an ample incision was made in the long axis of the tumor. The tenth rib was first resected subperiosteally to give access, and the involved rib was then removed from anterior to the tumor to and including the head of the rib, along with the attached intercostal muscles and underlying pleura. The muscles were closed over the defect. Postoperative recovery was uneventful and at present there is no clinical or x-ray evidence of recurrence.

In the gross the specimen was bony hard. The attached muscle tissue was intimately adherent to it. Microscopically, the mass was made up of dense sheets of cells with long spindle-shaped nuclei and varying amounts of cytoplasm, growing in irregular fashion. Distributed throughout these cells were many multinucleated bone cells about which there were deposits of new bone. It was regarded as an osteogenic sarcoma.

SUMMARY

Tumors of the chest wall comprise all growths affecting tissues of a similar character elsewhere in the body. While they do not present any special pathological characters they do, because of their location, present special surgical problems. The differentiation between benign and malignant growths in the fibrous and cartilage

groups is, as elsewhere, difficult and cannot be done on histologic appearances only. When operated upon by a surgeon unaccustomed to treating thoracic lesions, these tumors are perhaps likely to be removed incompletely because the surgeon fears to open the chest widely. They should be operated upon always with a closed type of anesthesia, preferably of the intralaryngeal or intratracheal type. The anesthetist as well as the surgeon should be accustomed to handling thoracic cases.

Radiotherapy cannot be expected to have much effect on most of the primary conditions and should be used as a rule, only when surgical removal is impossible.

Because they occur rather *infrequently* and are the most interesting of the group, case reports of the primary lesions of ribs and cartilages have been given in some detail.*

* Cases I, II, III, IV, V, XIII and XV were reported previously in *The Journal of Thoracic Surgery*, 9: 145–159, December, 1939.

A DEMONSTRABLE enlargement of the thyroid gland is present in almost all patients suffering from acute thyrotoxic disease, but not in all. In rare instances the gland is not obviously enlarged, but even in these a definite increase in size can be demonstrated at operation. One should not hesitate to diagnose exophthalmic goiter without a palpable thyroid if the other signs warrant.

RELATIVE FREQUENCY AND SITE OF PREDILECTION
OF INTRATHORACIC TUMORS*

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PRIMARY intrathoracic tumors are common. They may originate in the lung, in the mediastinum or from the various elements of the chest wall. By far the most important and frequent intrathoracic neoplasms are tumors of the lung, which are more properly termed bronchiogenic tumors because it has been established that practically all lung tumors are of bronchial origin and rarely arise from the lung parenchyma. Second in frequency are the various tumors of the mediastinum, and, third, the relatively rare neoplasms which begin in the chest wall and invade the thoracic cavity.

BRONCHIOGENIC TUMORS

Bronchiogenic tumors have until recently been considered a rare form of disease. During the past ten years, however, it has become more and more apparent that the incidence of endobronchial neoplasms is increasing and that bronchiogenic carcinoma is one of the most common forms of cancer. At the present time, carcinoma of the lung is of about the same frequency as carcinoma of the colon, and constitutes between 5 and 10 per cent of all cancers. Koletsky[1] in a study of 7,685 consecutive cases studied at autopsy found bronchiogenic carcinoma second only to carcinoma of the stomach. Kikuth,[2] Hirsche and Halpert,[3] Matz,[4] and many others, at postmortem observations, have found carcinoma of the lung either second or third in frequency, being preceded only by carcinoma of the stomach and carcinoma of the large bowel.

Another important observation has been made in various series of autopsy studies, namely, that more recent autopsy reports demonstrate a progressive increase in the frequency of pulmonary tumors. For example, Weller[5] at the University of Michigan found carcinoma of the lung occurred in 0.1 per cent of the first 1,000 autopsies performed at that institution. In the second 1,000 autopsies, the incidence was 0.5 per cent, and in 450 cases of the third 1,000 cases studied, the incidence was 0.8 per cent. Holzer[6] reports that in autopsy studies conducted between 1895 and 1904, only 1.04 per cent of all carcinomas discovered at postmortem were bronchiogenic in origin. Corresponding data from 1915 to 1924 showed an increase to 6.9 per cent. Ochsner and DeBakey[7] have further emphasized the steady increase of bronchiogenic carcinoma by a review of the death rates per 100,000 population in the United States who have died of malignant tumors of various kinds and are recorded by the mortality statistics of the Bureau of Census. These data show that from 1920 to 1936 there was no appreciable increase in the incidence of carcinoma of the stomach, uterus or gall bladder, whereas there was a marked increase in the incidence of carcinoma of the lung. The same authors have recently reported that in their experience carcinoma of the lung has increased approximately five times in the past seven years. This statement was based on a study of necropsy material at the Charity Hospital in New Orleans. Brines and Kenning[8] in a study of 936 patients with various types of tumors found carcinoma of the lung fourth in frequency. At the Barnes Hospital Chest Service, sixty-two proven cases of bronchiogenic carcinoma were seen in a

three-year period from 1933 to 1936. During the following three years, 117 bronchiogenic carcinoma cases were admitted for treatment. It becomes apparent, therefore, that the amazing increase in the incidence of bronchiogenic carcinoma cannot be attributed to improvements in diagnosis or increased awareness of the condition, but must be considered actual as demonstrated both by autopsy material and clinical observations.

It is now generally agreed that practically all pulmonary tumors arise from the bronchi. There has, however, been much confusion in classification of lung tumors because of the uncertainty of exact cellular origin and multiplicity of names which have been applied to the various lesions based on their microscopic appearances. This controversy does not, however, include true squamous cell cancer of the bronchus. Like squamous carcinoma in other locations, this variety of cancer occurs more frequently between the ages of forty and sixty, and is predominantly a disease of males. Other bronchiogenic carcinomas have been designated as round cell carcinomas, oat cell carcinomas, adenocarcinomas, depending upon the various arrangements of the cells. It is beyond the province of this paper to discuss in detail various controversial conceptions regarding classification of pulmonary tumors. However, it is necessary to mention briefly a few of the recent conceptions of pulmonary tumor formation to avoid confusion in the subsequent discussion of the localization of these tumors.

Endobronchial tumors which are sometimes classified as benign are rare as compared to true bronchiogenic carcinomas. The most common of this group is the so-called bronchial adenoma. These tumors may arise in any portion of the bronchial tree, but are more commonly found in the larger bronchi. The anatomic origin of bronchial adenomas may, therefore, be considered identical to that of bronchiogenic carcinomas. Unlike squamous cell carcinoma of the bronchus, these tumors

occur frequently in females and may appear at any age. Brunn and Goldman[9] report an incidence of 64 per cent in females in forty-two collected cases.

The tumors may be in the shape of a polyp attached to the bronchial mucosa by a small pedicle, but more often the intramural type is present where only a part of the tumor presents endobronchially. Not uncommonly, these tumors assume a dumbbell pattern, with the greatest portion of the neoplasm extending outside of the bronchus into the parenchyma of the lung. Brunn and Goldman[9] and others believe that the bronchial adenoma has such a distinct difference in appearance and growth potential that it deserves to be classified in an entirely different category from true bronchiogenic carcinoma. There is, however, a sharp difference of opinion on this point, and others, notably Womack and Graham,[10] believe that many endobronchial tumors, including bronchial adenomas, have a common origin, and are the result of the failure of embryonic bronchial buds to develop in a normal way. When the entodermic elements in the embryonic bud predominate, the tumor may be considered a bronchial adenoma, alveolar carcinoma, adenocarcinoma, etc. Mesodermic domination will result in what has been called by others chondroma, sarcoma, etc. Their conception is that these tumors should be considered potentially malignant, although they may be benign when first recognized. Frequently, these tumors resemble the mixed tumors of the salivary glands and it is not unusual to find in them cartilage and even bone. When malignant they manifest a markedly invasive quality but often without microscopic evidence of great activity of growth. Halpert[11] explains the formation of endobronchial tumors on the basis of what he terms reserve cells. These are undifferentiated entodermal cells capable of developing into ciliated epithelium, cylindrical cells, goblet cells, or may differentiate into any kind of epithelium that an entodermal cell is capable of producing. Another common classification of bronchio-

genic tumors is: (1) Squamous cell carcinoma; (2) small cell or undifferentiated cell carcinoma; (3) endocarcinoma. The confusion regarding classification of bronchiogenic tumors by the microscopic appearance does not, however, affect certain important facts concerning their site of predilection. For clinical purposes, all bronchiogenic tumors can be divided into two groups: (1) Tumors of peripheral origin, in which the lesion originates in minor bronchi, or from the periphery of the lung; (2) neoplasms originating in large or major bronchi.

Tuttle and Womack[12] have pointed out the differences in symptomatology and prognosis, depending upon whether the tumor originates in the periphery of the lung or near the pulmonary hilum. They have shown that tumors originating in the major bronchi are more slowly growing, probably because of the tough cartilage which must be penetrated if the neoplasm spreads by direct extension. Tumors of large bronchi produce symptoms earlier because obstruction or partial obstruction of the bronchus will result in atelectasis or pulmonary suppuration much earlier in the course of the disease than if the tumor is situated in a small peripheral bronchus.

In slightly more than half of the cases studied by Tuttle and Womack[12] the tumor was situated in a major bronchus. Boyd[13] and Edwards[14] found a somewhat higher incidence of centrally located tumors, the former finding only 10 per cent of the tumors located in the periphery, and the latter, 20 per cent.

In 216 patients with bronchiogenic carcinoma reported by Gebauer,[15] squamous cell carcinomas were situated in the major bronchi in 70 per cent of the cases. Tumors classified as adenocarcinoma arose in secondary bronchi in 90 per cent of the cases, and in the main bronchi, in only 10 per cent. Sixty-six per cent of tumors classified by Gebauer[15] as small cell carcinomas began in the main stem bronchi. Controversial opinions concerning histologic classifications make evaluation of these

data difficult. It is apparent, however, that in general the more slowly growing and better differentiated carcinomas have a tendency to arise in the major bronchi, whereas the rapidly growing, undifferentiated varieties of cancer usually originate in the smaller bronchi.

The relative frequency of involvement of the right and left lung does not vary enough to be of great practical importance. Fischer[16] studied 3,735 cases and found the right lung involved in 53 per cent of the cases, the left in 45 per cent, and a bilateral lesion overriding the carina in 2 per cent. Ochsner and DeBakey[7] collected 4,732 cases from the literature, and found right-sided involvement in 58.4 per cent, and left sided tumors in 41.6 per cent. In 784 of Fischer's[16] cases, 18 per cent of the tumors originated in the right main bronchus, and 14 per cent of the tumors were in the left main bronchus. The most frequent site of origin was in the right upper lobe bronchus, where approximately 19 per cent of the tumors were situated. The left upper lobe bronchus was the site of origin in 16.4 per cent of cases, the right lower lobe in 16 per cent, the left lower lobe in 13 per cent, and only in approximately 0.2 of the cases was the middle lobe bronchus involved. It is interesting to note that the superior divisions or dorsal divisions of the lower lobes are an infrequent site of tumor formation. In a series of 117 cases at the Barnes Hospital, we have seen only one instance of bronchiogenic carcinoma originating in this bronchial segment. This finding is particularly interesting because the superior divisions of the lower lobe are probably more frequently involved in lung abscess formation than any other portion of the lung.

Posterior Superior Sulcus Tumors. Tumors originating in the posterior superior sulcus of the thorax at the apex of the chest often produce a rather typical symptom complex consisting of unilateral pain in the shoulder girdle, Horner's syndrome, and paresis of the hand. Roentgenograms will usually show a mass confined to the posterior superior sulcus of the chest when these

symptoms are present. Pancoast[17] first described the symptom complex associated with the abnormal roentgenographic shadow, and it became the custom to refer to the condition as a Pancoast tumor. Ray[18] and others who have studied the so-called Pancoast tumor and its associated symptom complex are convinced that in the great majority of cases, the symptoms and roentgenographic findings are the result of invasion of the pleura by an ordinary bronchiogenic carcinoma and that neurofibromas, or any other tumor situated in the posteromesial portion of the chest, are capable of producing the same symptoms. It would seem, therefore, more proper to regard the term, Pancoast tumor, as a topical classification rather than a pathologic entity and to mention the condition in connection with bronchiogenic carcinomas.

RARE CONDITIONS WHICH SIMULATE PULMONARY TUMORS

Tuberculomas or calcified pulmonary abscesses may be indistinguishable from true pulmonary neoplasms until they are removed. Graham and Singer[19] reported three such cases in 1936, and later Haight[20] reported a calcified pseudotumor of the lung which proved to be a tuberculoma. Thoracic aneurysms may also be confused with intrathoracic neoplasms, although usually the true nature of the lesion can be determined by roentgenological examination. Graham[21] has reported two instances of nonpulsating aneurysms of the ductus arteriosus in which the positive diagnosis could be established only by exploration of the thorax. In two other cases at the Barnes Hospital, thoracic exploration was necessary to establish a positive diagnosis of aortic aneurysm in which pulsation could not be determined by fluoroscopy or by roentgen kymograms.

MEDIASTINAL TUMORS

Tumors of the mediastinum may be benign or malignant, but, except for rather rare cystic types of tumors, practically all mediastinal tumors are potentially malignant. The site of origin of mediastinal neoplasms is rather constant for each group, and a convenient method for describing them is to divide the various types into: (1) Tumors which usually originate in the anterior mediastinum; (2) posterior mediastinal tumors; (3) a miscellaneous group of comparatively rare neoplasms which may be located in any part of the mediastinum.

ANTERIOR MEDIASTINAL TUMORS

Lymphomas. A common variety of anterior mediastinal tumor arises from lymphatic tissue, and may be classified under the inclusive term of lymphomas. This group includes lymphosarcoma, Hodgkin's disease, so-called leukosarcoma, thymomas or any neoplasm which may originate in the lymphatic tissue situated in the mediastinum. Differentiation of the tumors of the lymphoma group from other types of anterior mediastinal tumors before treatment is undertaken is of primary importance because, in general, tumors composed of lymphatic tissue will react to roentgenotherapy and are not amenable to surgical extirpation. It is, therefore, the custom of many experienced thoracic surgeons to submit all patients with anterior mediastinal tumors to a test of roentgenotherapy. If the neoplasm decreases in size, the futility of surgical intervention is established. Confusion and controversy regarding the origin and relative frequency of tumors which arise from the lymphoid tissue in the mediastinum make a reliable estimate of the relative frequency of the various types of lymphomas impossible. Baldridge and Awe[22] have a workable classification for lymphogenous tissue, recognizing as the Hodgkin granuloma a sclerosing type of lesion, the lymphoblastic type as lymphosarcoma and the endothelial type as lymphoepithelioma. The lymphocytic type, they consider a manifestation of leukemia with or without blood changes. Ewing's[23] classification is based on three anatomic elements, namely, lymphocytes,

reticulum cells of the follicles and pulp, and endothelial cells. It is, however, often impossible to classify histologically the

sarcoma, and twenty-nine as Hodgkin's granuloma. In a series of eighty-seven cases of mediastinal tumors studied at the Barnes

Fig. 1. Lateral roentgenogram showing anterior position of a teratoid tumor of the mediastinum.

lymphomas of the anterior mediastinum which do not have other general manifestations of disease of the lymphatic system, or in which tissue is not available for biopsy. The same difficulties exist when one attempts to classify tumors of the thymus gland.

Heuer and Andrus[24] have been able to collect 230 cases of malignant thymomas. In their series of 145 cases of mediastinal tumors, studied at the New York Hospital, 32 per cent were considered lymphomas. Of these, eighteen were diagnosed lympho-

Hospital, in thirty-eight instances the tumor was classified as a lymphoma. In this group there was no other evidence of disease of the lymphatic system which could be demonstrated by involvement of other lymph-nodes or by changes in hemograms. In all instances the lesion diminished in size when roentgenotherapy was given.

Dermoids and Teratomas. Harrington[25] employs the term, teratoid tumors, for all dermoids and teratomas of the mediastinum. He feels that it is more accurate

than the inclusive term, dermoid tumors, because the majority of these neoplasms are derived from all three germinal layers.

FIG. 2. Photograph of teratoma of the mediastinum after successful surgical removal.

The structures of the teratoid tumors vary from thin walled cysts filled with cloudy fluid, or which may contain ectodermal derivatives such as skin, hair, or teeth, to solid tumors, depending upon the varieties of tissue which predominate. Heuer[24] has stated that the teratoid mediastinal tumors are the most common neoplasms of the mediastinum, but at the Barnes Hospital Chest Service, we have found that tumors of the lymphoma group occur more frequently than the teratoid variety. With the exception of the lymphomas, however, the incidence of teratoid tumors was more than twice that of any other kind of mediastinal neoplasm. Of 233 collected cases, including twenty-five at the Barnes Hospital, in only three instances has the tumor been reported to be in a posterior position in the mediastinum. These were in the cases of Krause,[26] Von Torok,[27] and of Smith.[28] In a series of 116 cases studied by Hedblom,[29] all of the tumors were in an anterior position. The mass was predominantly right-sided in sixty-three instances, and more apparent on the left in fifty-three cases. The teratoid tumors are thought to take their origin from cell rests probably of

branchiogenic elements which are drawn into the thorax by the descent of the heart and diaphragm. (Figs. 1 and 2.)

Mediastinal Thyroids. Thyroid tissue situated in a substernal position may produce an anterior mediastinal tumor which cannot be diagnosed definitely until the mass has been removed. In the great majority of cases, however, involvement of the thyroid tissue in the neck is rather obvious and will indicate the true nature of the lesion. Total or complete thoracic goiter may occur without cervical goiter, but this condition is rare.

Cysts of the Mediastinum. Thin walled cysts containing fluid have been given a variety of names including cystic hygromas, cystic lymphangiomas, and ciliated epithelial cysts. Cysts of the respiratory epithelium are often called bronchiogenic cysts. Lambert[30] has recently introduced convincing evidence that many cysts of the mediastinum arise from the pericardium through the defects in the process of its development. Forty-one instances of mediastinal cysts classified as either cystic hygromas, bronchiogenic cysts or cystic lymphangiomas are recorded in the literature. Five cases seen at the Barnes Hospital in which operation was performed successfully have been reclassified and are considered to originate from the pericardium, since Lambert's[30] conception of their origin has been known.

POSTERIOR MEDIASTINAL TUMORS

The most important group of neoplasms which arise from the posterior mediastinum are the primary nerve tumors. These neoplasms take origin from any of the elements of nerve tissue and may, therefore, be more precisely classified as ganglioneuromas, neurogenic sarcomas, neurofibromas, sympathicoblastoma, etc., depending upon the cellular element which predominates. Harrington[25] has employed the term perineural fibroblastoma in describing fourteen primary nerve tumors which he has treated surgically. He justifies the term perineural fibroblastoma by the fact that in each

instance the tumor was thought to arise from the sheath of the nerves. Thirteen of the group were benign tumors and one was

exactly the incidence of each type of primary nerve tumor which is recorded in the literature. Including thirteen cases

Fig. 3. Lateral roentgenogram showing usual posterior position of a primary nerve tumor.

considered malignant. Practically all primary nerve tumors have the common factor of being located in the posterior mediastinum and of being malignant or potentially malignant. Not infrequently, tumors which arise from the spinal or sympathetic nerves involve not only the posterior mediastinum but the vertebral canal, and assume an hour-glass or dumb-bell shape.

Difficulties in exact histological classification make it impossible to evaluate

treated surgically at the Barnes Hospital, 135 instances of neurogenic tumors of the posterior mediastinum are recorded. Twenty-two of these are considered neurofibromas, seventy ganglioneuromas, nineteen are considered neurinomas, (recorded by Heuer and Andrus)[24] and the remaining twenty-four as perineural fibroblastomas or simply as primary nerve tumors. Not infrequently, neurofibromas of the mediastinum may be associated with other stigmata of Von Recklinghausen's disease. This was the

case in one of our thirteen cases, and the condition has been recorded frequently in the literature. (Figs. 3 and 4.)

Carcinoma of the Mediastinum. Since it has been appreciated that pulmonary carcinoma is common and often invades the

FIG. 4. Photograph of neurofibroma of posterior mediastinum after successful removal.

RARE MEDIASTINAL TUMORS

Mediastinal Fibromas and Sarcomas. Thirty-two cases of fibroma of the mediastinum have been reported. In many instances, however, the diagnosis could be questioned, and it seems likely that confusion with fibrosarcoma or neurofibromas had occurred in many instances. The same difficulty arises when one attempts to evaluate the miscellaneous group of tumors included under the diagnosis of sarcoma of the mediastinum. These may arise from the malignant degeneration of chondromas, primary nerve tumors, or from any of the connective tissue elements of the lymphnodes or of the thymus. In our experience, it is often impossible to make an exact histologic classification of rapidly growing mediastinal sarcomas. In many instances, however, the positions and clinical aspects of the neoplasms have suggested that their origins were either from nerve tissue or the periosteum of the ribs.

mediastinum, fewer cases of carcinoma of the mediastinum have been reported. There is evidence that the thymus gland is the most common source of primary carcinomas of the mediastinum. In many instances, however, it is impossible to establish the exact origin. By far the most common cause of invasion of the mediastinum with carcinoma is extension or metastasis from a primary bronchiogenic tumor.

Mediastinal Tumors Arising from Bone and Cartilage. Chondromas, osteochondromas, chondromyxomas, enchondromas or chondromyxosarcomas may take their origin from the costal cartilages, sternum or spine and present in the mediastinum. All varieties are rare. Chondromas are more common in the anterior mediastinum arising from the costal cartilages, and all others of the group are more commonly located in a posterior position. Heuer[24] was able to collect only fourteen cases of mediastinal tumor which might be considered to originate from bone or cartilage.

Intrathoracic Cysts of Intestinal Structure. Nicholls,[31] of London, has reported the successful removal of an intrathoracic stomach and was able to collect twelve cases of intrathoracic cysts of intestinal structure from the literature. Graham[32] at the Barnes Hospital has had two cases of intrathoracic stomachs, one in an infant, and the other in a young man in whom the tumor of the mediastinum was discovered during an examination for admission to service in the army. In this case, the intrathoracic stomach was removed successfully, and the patient has now been admitted to military service. Two explanations have been advanced for the development of intrathoracic tumors of intestinal structure: (1) That they are cells from the foregut which remain in the thorax during the course of development; (2) that the cells are derived from the vitello-intestinal duct. In all of the cases reported by Nicholls[31] and in Graham's[32] two cases, the tumor was located in the posterior mediastinum. Twelve of the fifteen known cases were right-sided.

Lipomas of the Mediastinum. Intrathoracic lipomas may occur in a variety of forms, but are comparatively rare. Their anatomic location may be of three types: (1) Tumors in which an intrathoracic mass is continuous with an extrathoracic extension, causing the neoplasm to assume an hour-glass shape; (2) thoracic lipomas which extend into the neck; (3) lipomas which lie entirely within the thoracic cage. McCorkle et al.[33] have been able to record only thirty-four instances of thoracic lipoma from the world literature, including a case of their own. At the Barnes Hospital we have seen only two cases of lipomas of the mediastinum.

Mediastinal Xanthomas. Another unusual type of intrathoracic new growth has been called xanthoma by some, and sarcoma by others. The characteristic histologic finding in xanthomatous neoplasms is the xanthoma or foam cell. Phillips[34] recorded two cases which he had observed and collected 3 similar cases from the litera-ture. He considered this type of neoplasm to be nonmalignant and advised discontinuance of the term sarcomas in describing them.

TUMORS ORIGINATING IN THE CHEST WALL

It is frequently difficult to determine from published accounts of intrathoracic tumors whether their origin was actually in the mediastinum or from the chest wall. It is understandable why this situation can exist because it is often difficult to determine this point at operation or autopsy when the tumor is of large size. Tumors may arise from the ribs, the pleura or the nerves in the chest wall and manifest themselves as intrathoracic masses.

Benign intrathoracic tumors arising from the chest wall are rare. Harper[35] was able to collect sixty chondromas, nine fibromas, seven osteotomas, and eleven benign giant cell tumors reported in the world literature. These tumors usually do not invade the thorax but present as external masses. The tendency for all chondromas or osteochondromas of the chest wall to undergo malignant degeneration has been well established, and many believe that a large proportion of cases of intrathoracic sarcomas begin as benign chondromas or neurofibromas.

A great variety of tumors which may arise from the pleura have been described. These may be benign or malignant, primary or metastatic. Fibromas, lipomas, myxomas, angiomas, various types of sarcomas, including myxosarcoma, round cell, spindle cell and fibrosarcoma have been described. All of these tumors are rare and require no particular comment.

Epithelioma of the pleura is probably a misnomer. Robertson[36] has shown that primary malignant tumors of pleural tissue are probably always sarcomas and that the great majority of so-called endotheliomas of the pleura represent extension or implantations of carcinoma from another primary source, usually the lung.

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TUMORS OF THE THYMIC REGION AND MYASTHENIA GRAVIS

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THE etiology of myasthenia gravis is unknown and the functions of the thymus gland are unknown, therefore, it is apparent that one enters a field of speculation if one attempts to consider the relationship of abnormalities of the thymus to myasthenia gravis. It is known that myasthenia gravis is a disease characterized by abnormal fatigability of muscles, usually by characteristic lymphocytic infiltration of these and other organs and frequently by failure of involution or neoplasm of the thymus. It is known that benign tumors of the thymus are rare and that most of those that have been reported have been present in patients with myasthenia gravis. The frequent association of the two would appear to be more than a coincidence.

The first description of a thymic tumor in association with myasthenia gravis was that by Weigert[1] in 1901. Bell,[2] in 1917, collected from the literature an account of fifty-six cases of myasthenia gravis in which either an operation or an autopsy had been performed and twenty-seven of these exhibited abnormalities of the thymus. A diagnosis of thymoma was made in ten and the remaining seventeen patients were considered as having either a persistent or an enlarged thymus. Norris[3] restudied the problem in 1936 and found that there were thirty-five lesions of the thymus in a total of eighty necropsy reports on patients with myasthenia. He expressed the opinion that pathologic changes may be found in the thymus in cases of myasthenia gravis in direct ratio to the care with which they are sought. In 1939, Blalock, Mason, Morgan and Riven[4] found eighteen additional cases in the literature and reported one of their own.

Thus, up to 1940 there had been reported fifty-four instances of abnormalities of the thymus in approximately 110 autopsies or operations on patients with myasthenia gravis. Additional cases have been reported since that time. Miller[5] described the autopsy findings on five patients with myasthenia gravis, two of whom had an encapsulated tumor of the thymus and two had a persistent thymus. Undoubtedly, a good many cases have not been reported. For example, Dr. E. H. Campbell of Albany, New York, has removed recently typical thymomas from two patients with myasthenia gravis.

The presence of an abnormality of the thymus should be suspected in every patient with myasthenia gravis. Definite enlargements or tumors may be demonstrated by fluoroscopic or x-ray examination. A film taken in the lateral position is usually best for demonstrating the lesion.

One cannot make dogmatic statements concerning the effects of the removal of thymomas upon the course of myasthenia gravis. This is due to two reasons: In the first place, there have been too few such operations to allow critical judgment. The most striking result is that reported by Blalock, Mason, Morgan and Riven.[4] This patient, previously a severe myasthenic, has been well now [for five years following thymectomy. In the second place, spontaneous remissions are not uncommon and apparent beneficial postoperative effects may be explainable on this basis.

The operation is a relatively simple one. An upper median sternotomy gives an excellent exposure and the tumors can usually be shelled out without difficulty. It is obvious that either the patient should

be in a remission at the time of the operation or one should be able to control the disease by the use of prostigmin or some other drug. Since myasthenia gravis is a disabling disease and since the operative procedure is not a very grave one, it would appear that the encouraging experiences indicate the advisability of the surgical removal of clinically demonstrable thymic tumors in patients with myasthenia gravis.

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USUALLY in thyrotoxicosis the tendon reflexes are exaggerated. In the beginning and in milder cases they are normal. Late in the disease the reflexes are sometimes lost but in that event other causes for their absence should be sought.

INTRATHORACIC GOITER

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THE fact that certain goiters are partly or wholly intrathoracic is now accepted as a serious and not uncommon pathologic condition. When one considers that many of these goiters are completely hidden in the bony thorax, however, it is not surprising that only in recent medical times has much been known of this disease. Intrathoracic goiter was first described anatomically by A. Haller in 1749.[1] It was much later, in 1830, when C. Lingl[2] gave the first clinical description of this lesion.

M. Dubourg,[3] in 1826, recorded an instance of strangulation and death due to intrathoracic goiter, and in 1828 A. Adelman[4] reported a case of malignant disease in this type of goiter. The term, "goiter plongeant," was coined by Malard in 1851[5] to apply to those substernal adenomas which popped up into view above the sternum with increased intrathoracic pressure. The monograph, "Die Struma Intrathoracica," by F. Wuehrman, in 1896[6] was the most comprehensive study to that date.

The recognition of intrathoracic goiter in the earlier years was, of course, limited by the lack of roentgen diagnosis until 1899. At this time Schieff[7] added another most important milestone to the understanding of this disease by showing the value of the x-ray in the diagnosis of intrathoracic goiter.

It is interesting today to note that the classical descriptions of exophthalmic goiter by Parry, Graves, and Basedow, as quoted by Major,[8] failed to include any case in which the symptoms and signs were those of a goiter extending into the thorax below the sternum. This finding is in accord with present day experience that the thyroid gland in typical exophthalmic goiter rarely, if ever, extends deeply into the thorax. One cannot but wonder if these writers saw no cases of hyperthyroidism due to a sub-sternal adenomatous goiter which were difficult of explanation.

Considerable confusion has existed in descriptions of intrathoracic goiter because of different nomenclatures used by various authors. Inclusion of the terms, "substernal" and "retrosternal" and "subclavicular," under the single grouping of "intrathoracic" goiter seems amply justified and has been fairly well accepted. From 12 to 30 per cent of all goiters could be so classified according to various reports.[1,4,8,9] Some authors, however, prefer to limit the term, "intrathoracic," to those goiters which extend down to or below the arch of the aorta. If this more rigid definition is followed, incidence of intrathoracic goiter ranges from less than 1 to 10 per cent of all goiters operated upon.[10,11,12]

Intrathoracic goiter arising from ectopic thyroid tissue deep within the mediastinum is quite rare. The case of Means[11] in which the mass rested on the diaphragm may fall into this category. From embryologic considerations such glands should lie in close relationship to the aortic arch or possibly the tracheal bifurcation. They may or may not be connected with the thyroid proper by a fibrous cord.[1]

Ptosis of the normal thyroid gland, or a slight dipping down of cervical goiter behind sternum or clavicles should not be classified as intrathoracic goiter, since only part of such goiters are at best subclavicular.

Intrathoracic goiters develop when a single adenoma or one or more of the nodules of a multiple adenomatous goiter descend through the superior thoracic strait into the bony thorax. Most frequently intrathoracic goiters arise from adenomatous goiters, but occasionally a single discrete adenoma which once lay in the lower pole of one thyroid lobe will

descend into the thorax. The descent of these single or multiple nodules into the thorax depends first on their location in the gland. Obviously, a discrete nodule located in the superior pole of the thyroid gland would not find its way into the chest. When, however, the nodule is present in the lower portion of either of the thyroid lobes or of the thyroid isthmus, it may, as it grows in size, readily descend through the superior thoracic strait. One of the factors that influences this descent is the rate of growth which usually is so slow that it requires years for the goiter to enter the thorax. It is, of course, occasionally true that a low-lying discrete adenoma in a young person will have a hemorrhage into it, and since the least resistance to its expansion is in the downward direction, it will so descend into the chest. Whether the growth of these adenomas of the thyroid is rapid or slow, there is nothing but loose cellular tissue to restrict their descent into the thorax through the superior strait. Expansion in other directions is limited by muscles, fascia, vessels or bone. The descent of these low-lying adenomas is furthermore aided very markedly by the contractions of the sternomastoid muscles and of the prethyroid muscles that accompany motions of the head and acts of respiration and deglutition and to some degree by the force of gravity itself.

ANATOMY

The anatomical relation of intrathoracic goiters is most important, not only in considering the effects of these thoracic masses upon adjacent structures but also in the surgical management of their removal. It must be recognized that all, or practically all, intrathoracic goiters lie in the closest association to the trachea, and this relationship to the treachea is one of the important factors in their diagnosis and in their surgical management. It is perfectly obvious, when one considers the origin of the intrathoracic masses from an adenomatous enlargement of the thyroid gland surrounding the trachea, that the intrathoracic portion of the goiter may lie either to the right, to the left, in front of, or behind the trachea. Furthermore, in some cases the adenomatous mass may entirely encircle the trachea with extensions running backward from each lobe. Most commonly, intrathoracic goiters extend from the lower pole of either the right lobe or the left lobe of the thyroid directly down along the trachea into the superior mediastinum. Less common, in fact quite unusual, is the type in which adenomatous nodules grow backward between the branches of the inferior thyroid artery and then go downward behind the trachea. This type is occasionally overlooked in goiter operations because the intrathoracic portion lies out of sight behind the thyroid lobe in the neck.

The arterial supply to intrathoracic goiters comes from the same arteries that supply the normal thyroid gland. Both the superior and inferior thyroid artery have considerable slackness due to their winding course from the major arterial trunk to the thyroid gland. This is most important, not only because it permits portions of the thyroid gland to descend with their arterial supply intact but also because it permits control of the blood supply of intrathoracic goiters by controlling the major thyroid arteries in the neck. The superior thyroid artery, after it leaves the external carotid artery, goes up the neck somewhat and then curves downward to join the superior thyroid pole. The inferior thyroid artery, after it leaves the thyroid axis of the subclavian artery, goes up the neck in quite a wide arch, and after passing beneath the carotid artery and the jugular vein at a level just below the superior thyroid pole, descends along the gland and enters it in the lower or middle portion of the lobe. It is apparent from this distribution of these two major arteries that if structural changes in the thyroid gland occur, and the lobe or part of the lobe descends into the chest, there is sufficient laxity in these arteries to permit them to descend with the lobe. Certainly there is nothing in their

anatomical arrangement which at the start of the descent of the goiter into the thorax exerts tension to hinder this process. The veins coming from the thyroid gland empty in large part into the internal jugular vein, and it seems to be possible for these veins also to elongate as part of the thyroid lobe descends into the thorax. Almost never have we had any significant venus bleeding from within the thorax when a discrete adnomatous mass was lifted out of the chest. The veins all come up with the mass and lead into the jugular vein at a level which usually is readily seen in the operative wound in the neck. These anatomical arrangements of the arteries and veins are most important, then, in the surgical removal of intrathoracic goiters.

The effect that the descent of thyroid adenomas into the thorax has upon the recurrent laryngeal nerve will vary, of course, with the location of the thyroid mass before it starts downward into the chest. It is, nevertheless, true that in most instances, in spite of the presence of deep intrathoracic goiters, there is no vocal cord paralysis. In the past it has been said that when vocal cord paralysis was present one could be quite certain that malignant degeneration of the intrathoracic mass had occurred. This, however, we now know to be a mistake, because we have several times seen preoperative paralysis of one cord in the presence of large substernal goiters in which there was no evidence of malignancy. Whether the substernal goiter pushes the recurrent laryngeal nerve backward as it descends, or in occasional cases in which the goiter descends between branches of the inferior thyroid artery, presses it forward, will of course depend on the point of origin of the goiter. It is our experience, however, that in most cases the recurrent nerve is pushed backward and is well out of the way of the surgeon at the time of the operation.

PATHOLOGY

Most intrathoracic goiters, as we have said, arise from a multiple adenomatous

goiter, or the so-called nodular goiter. Less often they result from the descent into the thorax of a single discrete adenoma. Whichever of these two basic pathological factors is present, the intrathoracic goiter is subject to the same degenerative changes that may occur in a goiter which is entirely cervical in location.

Hyperplasia of the intrathoracic thyroid tissue can occur, and in fact, not infrequently does. This results in the development of toxic symptoms, and we have a clinical picture here very little different from that seen in toxic adenomatous goiter when it is in the usual position in the neck. Degenerative changes may occur in the substernal mass with necrosis, hemorrhage and cyst formation. Occasionally, such cysts become very large and produce very serious pressure symptoms. Calcification in varying degree may occur in the intrathoracic goiter, presumably because intrathoracic goiters are goiters which have been present for many years. In some cases malignant degeneration occurs just as it does in nodular goiter in the neck. The malignancy may be diffuse, invading all the structures and going outside of the thyroid capsule, or it may be localized within a discrete adenoma. It may be of any of the types that one sees in thyroid pathology in the neck.

PHYSIOLOGY

Changes in the physiology due to the presence of an intrathoracic goiter are related first to the possibility that hyperthyroidism has developed because of hyperplasia in the intrathoracic mass. This hyperthyroidism is in no way different, in our experience, from the hyperthyroidism that comes from nodular goiter in people of middle life and beyond. Its presence, of course, adds distinctly to the risk of removal of the intrathoracic goiter, just as the presence of hyperthyroidism adds appreciably to the removal of any large goiter.

The changes in the physiology which are specifically related to the anatomical posi-

tion of the goiter in the thorax are all changes which are due to the presence of an intrathoracic mass, and depend on the rowed that the patient has a constant stridor on inhalation. In certain instances the patient finds that there are certain

FIG. 1. (L. Y.) This anteroposterior x-ray exposed for soft tissue visualization shows the trachea bowed to the left and narrowed to less than half normal size by the pressure of a single large intrathoracic adenoma arising from the right lobe of the thyroid. Tilting of the larynx away from the affected side is well demonstrated.

pressure of this mass on the surrounding structures. The trachea is the earliest organ to show the effect of this pressure. It is deviated from its midline position by the presence of the substernal mass. If the substernal mass lies on both the right and the left side of the trachea, then it is, of course, narrowed by this bilateral pressure. If the goiter lies behind the trachea, the trachea may be broadened laterally and at the same time its lumen narrowed antero-posteriorly by the enlarging goiter forcing it against the sternum. A similar condition may arise when the goiter lies in front of the trachea and pushes the trachea backward toward the spine. The degree of tracheal pressure will, of course, depend on the size of the substernal goiter and the amount of tracheal deviation present. In some cases the trachea becomes so nar-

positions of the head in which pressure on the trachea is very much increased and he consciously avoids these positions. Thus we have patients who cannot sleep with their head bent sharply forward because this obstructs their breathing. Others cannot lie on one side or the other in bed because again the trachea is bent over the substernal mass and is definitely narrowed by this mechanical change in its position. It is interesting to observe that very rarely does a substernal goiter affect the course of the esophagus.

Physiological effects from the presence of an intrathoracic mass rarely make any changes on the recurrent laryngeal nerve or other nerves in the neck. In a few instances, however, unilateral vocal cord paralysis has occurred in our experience probably due to stretching of the recurrent

laryngeal nerve. The presence of this paralysis in the recurrent nerve may not be recognized by the patient and will be found

individuals that puffiness of the face and duskiness of color are distinctly noticeable and very large dilated veins are plainly
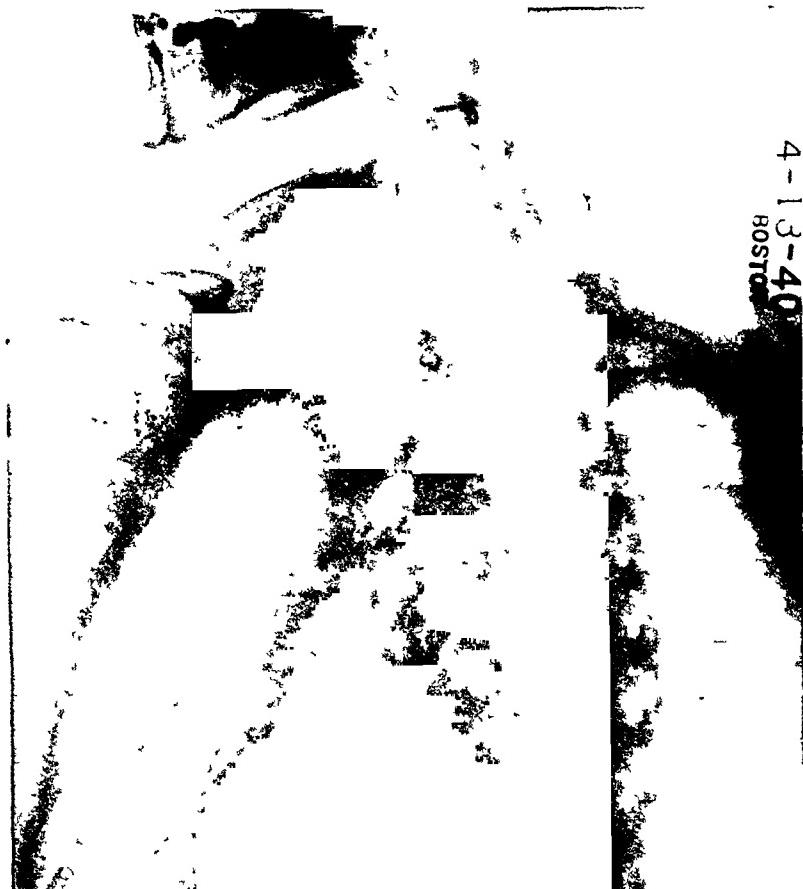
Fig. 2. (M. R.) An obliquely lateral x-ray in this case demonstrates deviation of the trachea backward with compression by an intrathoracic goiter at level of the manubrium sterni. At one point the trachea is narrowed to one-third normal diameter. The size of the soft tissue mass is clearly shown.

only by routine examination of the vocal cords. In other instances, however, goiter patients consult the physician because of the fact that they have recently developed hoarseness and this may be the first symptom of a substernal goiter.

In patients who have very large intrathoracic goiters, there is sufficient pressure of the goiter against the venous structures coming down through the superior thoracic strait to produce definite engorgement of the veins in the neck and over the chest wall. Such venous engorgement is very marked in certain large goiters, and yet, curiously enough, in other deep intrathoracic thyroid tumors there will be little or no venous engorgement. The venous engorgement may be so marked in some

visible over the neck and upper anterior chest wall.

DIAGNOSIS

The diagnosis of intrathoracic goiter can be made, not infrequently, from careful consideration of the patient's history, but in many instances it is made only by clinical and x-ray examination. The clinical symptoms that are suggestive of intrathoracic goiter are varied, but most of them are the result of pressure of the intrathoracic mass on the trachea, on veins or on the recurrent laryngeal nerve.

Occasionally, a patient is seen who says that she had a goiter many years ago, but that it "disappeared." When a definite sizeable mass in the area of the thyroid
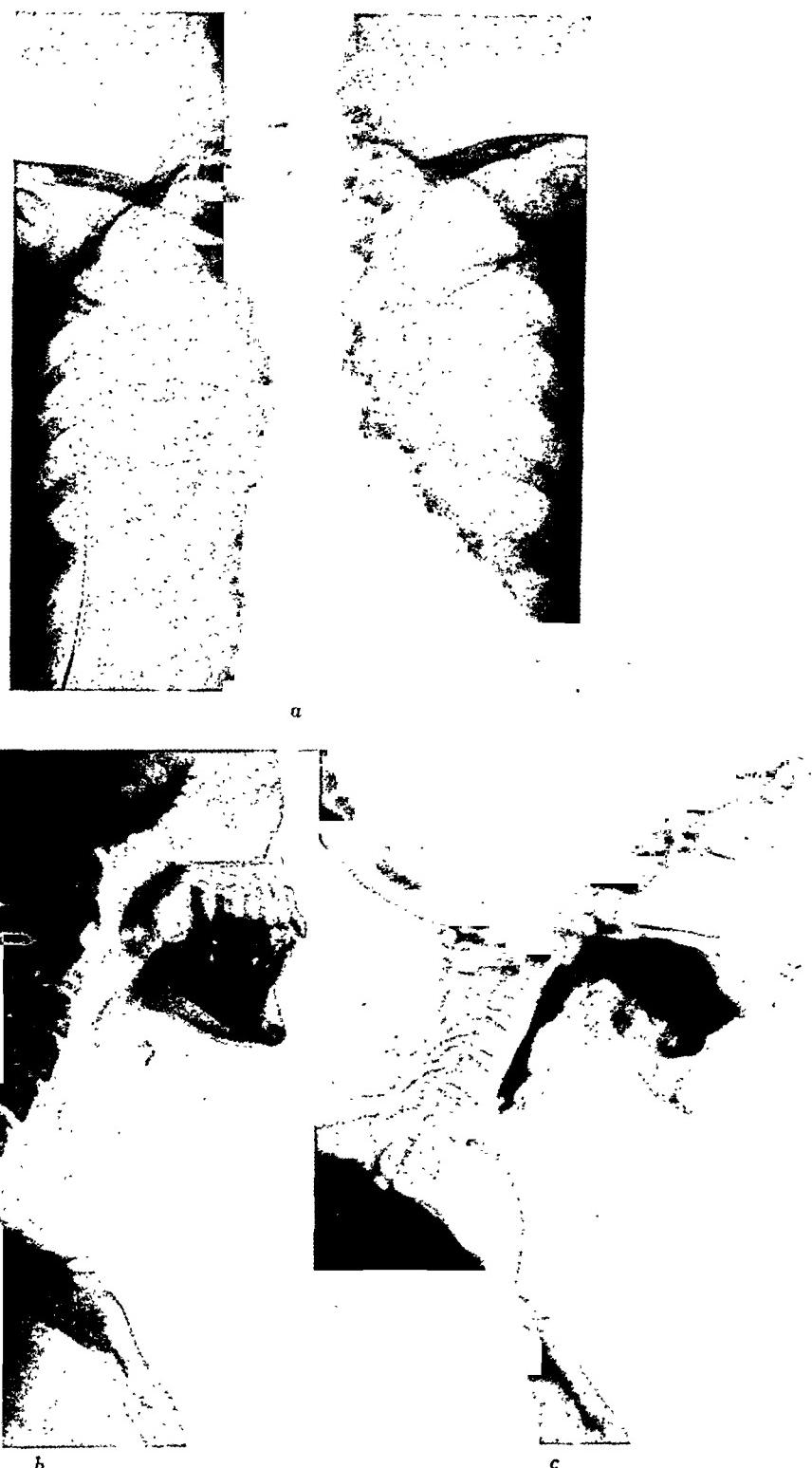
FIG. 3. (M. C.) In the anteroposterior x-ray (a) of this patient, the trachea is barely visualized, but apparently nearly in the midline. A soft tissue mass is shown extending below the aortic arch, particularly on the right. A lateral film (b) demonstrates marked anterior deviation of the trachea with narrowing of its lumen. Barium swallow (c) indicates that the goiter lies behind the esophagus also, this structure being pushed forward with the trachea.

"disappears," one may be very suspicious that it has descended through the superior thoracic strait and so passed from view.

hoarseness, and not infrequently the discovery of paralysis of one vocal cord by a physician, leads to the search for a possible

a   *b*

Fig. 4. (A. F.) Deviation of the trachea backward and to the right by the pressure of an intrathoracic goiter are shown (*a*) in the lateral and (*b*) anteroposterior x-rays. These are the usual views taken in x-ray diagnosis of intrathoracic goiter.

More commonly the patient's history states that there has been an increasing sense of pressure in the throat. Occasionally, this pressure takes the form of a lump in the throat which is noticeable when solid foods are swallowed. In well developed intrathoracic goiters the patient notices very definitely the stridor and difficulty of breathing that accompany narrowing of the trachea.

When the intrathoracic mass lies on one side of the trachea and pushes the trachea well away from the midline, the patient will not infrequently state that when she lies with her head on the side at which the goiter is, she has obstruction in breathing; and when she lies with her head on the side away from the goiter, there is less trouble in breathing. The mechanics of this arrangement are perfectly logical and readily understandable.

In some patients the development of

substernal goiter. In other instances the gradual development over a period of years of increasingly large veins at the base of the neck and over the upper chest, likewise show the possible presence of substernal goiter.

In some individuals the development of hyperthyroidism, in the absence of any apparent goiter in the neck, may lead the physician to search for a substernal goiter. The presence of real hyperthyroidism with no palpable enlargement of the thyroid gland in the neck should make any physician consider the possibility of an adenomatous goiter beneath the sternum in the mediastinum.

The physical signs that accompany the presence of substernal goiter are varied. In the normal individual one can, with considerable practice, palpate the upper pole and the lower pole of both the right and left lobes of the thyroid. If the thyroid is

enlarged, this palpation of the poles is much simpler. If then, in the presence of an adenomatous goiter, one can feel the superior pole on each lobe, and the inferior pole on one side, but is quite unable to get beneath the inferior pole and feel its lower borders on the other side, he at once becomes suspicious, if not certain, that there is a substernal extension and an intrathoracic goiter.

In some patients there is a discrete adenoma beneath the sternum which rises in the neck when the patient coughs or sneezes or in any other way increases the intrathoracic pressure. This ability of a discrete adenoma in the superior mediastinum to rise up into the neck is not commonly seen but when present is diagnostic. Intrathoracic goiters, when one can palpate their superior borders or watch them with the fluoroscope, move up and down with deglutition just as do goiters in the neck. This movement with deglutition helps to differentiate the intrathoracic goiter from intrathoracic dermoids or other tumors.

We have never found percussion of the superior mediastinum and increase in the dullness of this area of great help to us in the diagnosis of substernal goiter. Most substernal goiters show, in some degree at least, in the neck, or can be palpated in the sternal notch or just to one side beneath the sternomastoid. When such a mass is felt and when it rises with deglutition, percussion may help the examiner in deciding that there is a larger mass beneath the sternum.

The diagnosis of substernal goiter can almost invariably be made by satisfactory and adequate x-rays of the superior mediastinum. The x-ray technician must understand that his pictures must be sufficiently soft to show the outline of the trachea, and the patient must have the trachea filled with air and hold his breath while the picture is taken. It is very important that not only anteroposterior views of the trachea and the superior mediastinum are taken, but also that lateral views as well are obtained.

A discrete adenoma lying just beneath the manubrium of the sternum and directly on the trachea may make no great impression on the anteroposterior picture of the trachea, and certainly the trachea will not be deviated either to the right or the left of the midline. However, a lateral view of the trachea in this same case will show its marked deviation posteriorally, due to the presence of this goiter in front of it. A similar situation is obtained when the goiter is behind the trachea and pushes the trachea forward rather than laterally. In some instances x-rays are taken while the patient is swallowing a barium mixture, in order to show the relation of the esophagus to the trachea and to the goiter. This has been very helpful to show the position of the intrathoracic mass. In many cases of intrathoracic goiter, the goiter itself will not show in the x-ray and its presence will be known only because of its deviation from the normal position in the midline of the trachea. In other cases, however, when the goiter is very large or when it contains much calcified material, the actual shadow of the goiter itself will be visible; and as x-ray technicians become more expert in their tracheal pictures, the actual shadow of the goiter is more likely to appear in the plates.

TREATMENT

The treatment of intrathoracic goiter is surgical removal, and it is unnecessary to state that the earlier in the course of development of a substernal goiter surgery is undertaken, the easier, simpler and safer is the surgical procedure.

It has been surprising to us to note in many instances the size of intrathoracic goiters that can be removed through the superior thoracic straits without cutting the sternum or freeing the sternoclavicular articulation. In fact, the senior writer in his entire experience has never had occasion to enlarge the bony thoracic strait for the removal of a substernal goiter, nor has he yet encountered such a large noncancerous intrathoracic goiter that it could not be re-

moved without enlarging the bony thoracic straits.

The anesthesia for the removal of intrathoracic goiters is, of course, of the utmost importance. Here particularly is it necessary to have an anesthetist trained in goiter surgery, and adept in handling the specific problems that arise when a trachea is distorted in position and narrowed in its caliber. We now prefer, and routinely use, intratracheal anesthesia with cyclopropane and oxygen for anesthetic agents. This is the most satisfactory arrangement in our experience. The only objection to it, and it is not a serious one, is that the intratracheal catheter is somewhat stiff and somewhat resistant when one is attempting to dislocate the intrathoracic mass; and it does not bend and give as much as the trachea would if the catheter were not inside of it. However, the fact that anoxemia cannot occur and that the patient's respiratory process is under the control of the anesthetist, far outbalances the slight mechanical objection to the catheter in the trachea.

The first requirement in the surgical removal of an intrathoracic goiter is a wide incision. The usual transverse cervical incision is made above the clavicle, the skin flap lifted and the muscles split in the midline longitudinally. The sternomastoid is then freed from the prethyroid muscles on each side, and the prethyroid muscles are clamped and cut on each side, even though the substernal goiter is present on only one side. This cutting of the muscles on the uninvolved side is not necessary in small tumors, but in large growths it is very helpful, because it gives a great deal of freedom for the lobe of the thyroid on that side to move when the manipulations for the extirpation of the goiter in the chest are going on.

When the field is thoroughly exposed by wide cutting of the prethyroid muscles and thoroughly dry, a careful exploratory finger is placed along the posterior surface of the capsule covering the intrathoracic goiter. Gentleness is most important at this stage, and as the finger sweeps around the capsule

and comes forward, one meets the venous trunks which run from the goiter to the jugular vein. If the finger is gently hooked onto these, they can be caught with snaps, cut and tied at once. This relieves a great deal of the bleeding which might otherwise be present if the goiter were quickly extirpated. In some instances it is desirable to catch, cut and tie the superior thyroid artery in order to gain greater freedom of motion of the involved lobe of the gland. This, however, is by no means always necessary.

With the veins now tied, the finger is gently swept around the substernal mass keeping most carefully and gently in the proper line of cleavage. If one gets away from this, hemorrhage occurs or one breaks into the pleural cavity. Therefore, it is most important that adequate time and gentleness be employed at this stage to free the capsule of the mass from the adherent surrounding tissue. In some cases, at this stage of the procedure, the goiter can be somewhat lifted forward and the inferior thyroid artery seen, caught, tied and cut. In other cases, however, one cannot get at the inferior artery until the mass is fully delivered from the chest.

When the intrathoracic mass is delivered into the neck, a wet gauze pack is immediately slipped down into the cavity from which it came. This is done to prevent any sudden expulsive cough from causing undue pressure on the pleura and rupture of the pleural cavity, and also to control any ooze from nearby veins that may be occurring. With the goiter now delivered into the neck and in clear vision, the course of the inferior thyroid artery can usually be seen, and occasionally the recurrent laryngeal nerve can also be seen and more thoroughly avoided. Usually, however, the nerve is not seen, and one proceeds at once with the removal of the intrathoracic mass. Due care is taken to avoid injury to the trachea which one must recall may well be distorted by the delivery of the tumor. Also, great care must be taken to inspect the surface of the mass for parathyroids and to protect

these and leave them behind as one proceeds with the excision of the goiter.

When the intrathoracic goiter is removed and hemostasis is complete, a cigarette drain with a very small amount of gauze protruding is placed into the intrathoracic cavity from which the goiter came. Almost never has it been necessary for us to pack this cavity with gauze, but a drain is desirable because not infrequently sero-sanguineous fluid will collect in the cavity and have to be released if drainage is not instituted at operation. It is our custom to start pulling the drain out slowly on the fourth day and to have it completely removed on the sixth or seventh day, unless undue amount of discharge is present.

As we have said before, most substernal goiters can be delivered intact without any rupture of the capsule that surrounds them. This is made possible by gentle, slow dissection with the fingers which finally encompass the entire goiter, and then the slow deliverance of the goiter by a finger beneath the lowermost pole. Occasionally, however, the goiter is so large that it cannot be brought through the superior thoracic strait intact, and one can then readily put a finger through the capsule at the upper portion of the intrathoracic mass and rupture it, permitting the soft, jelly-like contents to ooze out. When this has happened, the mass becomes much smaller and then almost invariably can be teased up through the superior thoracic strait. The bleeding which accompanies this rupture of the capsule is not great nor troublesome and is readily controlled when the entire tumor is delivered and the major blood vessels are caught and tied.

CONCLUSIONS

Intrathoracic goiter is not an infrequent disease and one with possibly serious effects if not recognized and treated sufficiently early.

Certain features of the history and physical examination usually suggest the presence of intrathoracic goiter. The x-ray offers important and frequently diagnostic information by revealing deviation and compression of the trachea and less often the soft tissue mass causing this.

With rare exceptions intrathoracic goiters may be removed safely by appropriate surgical methods.

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CARCINOMA OF THE LUNG AS A SURGICAL PROBLEM*

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A SOLID front must be developed among forces fighting a disease which gives quarter for a short time in its life history and then invariably causes death. All members of the profession must be on the alert at all times for cancer which may still be in its early stage. Cancer of the lung is no exception. We cannot be held to task so definitely for the lives of patients who have metastatic disease when they first consult us. For that group our educational program may be at fault. There are also those unfortunate few whose malignant lesion progresses to the incurable stage without the production of symptoms. The profession cannot escape its responsibility, however, to that large group of patients who come to us for help while their pulmonary cancer is still confined to its original site.

From a practical point of view right now, doctors can help patients with cancer of the lung more effectively by first, speeding up the mechanism of discovery; second, agreeing on proper management for the patient who has either a suspected or proved cancer; third, appraising the condition of the patient properly as to operability; and fourth, recognizing the value of surgical exploration in patients presenting presumptive evidence of cancer but in whom the diagnosis is unverified histologically. It is the purpose of this paper to discuss primary cancer of the lung as a surgical problem with particular reference to these four points. A résumé will be given of the results of a clinical study in 174 patients suspected of having pulmonary carcinoma in whom tissue verification was obtained in 127.

PROGRESS ANTICIPATED IN EARLY DISCOVERY

When contributing factors to early discovery of cancer of the lung are weighed in the balance, the scales tip well toward the hopeful side. There are four factors upon which an optimistic point of view is based. (1) The frequency of cancer of the lung will force the profession to be constantly on the lookout for it. (2) Early telltale symptoms do develop which will give the first doctor consulted a clue as to a possible organic chest lesion. (3) The chest lends itself well to contrasting shadows on the x-ray film and will yield presumptive evidence of an early lesion. (4) In the earliest stages the majority of the growths can be diagnosed with certainty. Three-fourths of the lesions originate in one of the main bronchi and are visible and can be biopsied bronchoscopically.

General interest in cancer of the lung is being forced upon the profession by the established fact of its frequency. Malignancy in this location is now near the top of the list as a cause of death from cancer. Even as late as five years ago, autopsy statistics seemed unbelievable when it was reported that carcinoma of the lung accounted for 10 per cent of all deaths caused by cancer, and was exceeded only by lesions which originated in the stomach and colon. An absolute as well as relative increase in the frequency of cancer of the lung is generally conceded. Ochsner and DeBakey,[1] after making a survey on the relative frequency of various types of cancer, stated, "During the period 1920–1936, inclusive, the incidence of cancer of the stomach and duodenum, of the liver and gall bladder, and of the uterus and of the skin showed little, if any, increase. The incidence of cancer of the lung showed a progressive rise throughout the United States." They found the death rate for carcinoma of the lung in 1936 to be 3.6 per hundred thousand, whereas in 1920 the rate was only 1.1. These authors also reported that cancer of

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the lung as found at necropsy in the Charity Hospital in New Orleans had increased five times in the past seven years. In 1938, as a cause of death, cancer of the lung even exceeded cancer of the stomach in frequency. Together with the numerical increase in cases coming under clinical observation, the literature on the subject has swelled tremendously. No doctor will be permitted to forget that the lung is a common site for malignancy.

The first factor then which will speed up the mechanism of early discovery will be the development of a full appreciation of the *possible presence of malignancy in any* patient complaining of chest symptoms. In the past there has been too long an interval between the time the doctor first saw the patient and the time when he began to suspect that there might be a serious organic lesion. In our series of cases, records show that the average interval between the time of the first visit to a doctor and the first x-ray was six and one-quarter months. This interval can be shortened to a matter of days or weeks, instead of over one-half a year.

SYMPTOMS AND PHYSICAL SIGNS NOTABLY UNRELIABLE

What is the clue to possible early cancer of the lung? The great majority of patients who harbor primary malignancy of the lung do have symptoms which point the diagnostic finger at the chest. Ninety-eight per cent of the patients in our series complained of some chest symptoms, and the great majority of the chest symptoms came early in the course of the disease.

The study of frequency and sequence of symptoms by various authors has resulted in common agreement on the following points: (a) There is no characteristic symptom complex in carcinoma of the lung. The condition may simulate many other diseases of the lung. (b) Chronic cough is by far the most frequent and therefore the most important of all symptoms. If there has been an habitual cough for years, a change in the character and frequency of the cough is significant. Eighty-seven per cent of the patients in our series complained of cough. (c) Attention may be first directed to the chest by symptoms of a respiratory infection of a chest cold. Persistence of symptoms, signs, or x-ray changes may be indicative of bronchial occlusion and tumor. (d) Important, but less frequent symptoms, are hemoptysis, chest discomfort or pain and wheezing. Gastrointestinal disturbances may be present especially if the left lower lobe bronchus is involved. (e) Dyspnea, weight loss and *symptoms related to accumulation of fluid* in the pleural cavity are late signs. Therefore, such symptoms need not be discussed in a consideration of early diagnosis.

It has been our experience that carcinoma of the lung has been mistaken for tuberculosis more frequently than any other pulmonary disease. Other erroneous diagnoses were also made, such as unresolved pneumonia, bronchitis, asthma, pleurisy and empyema.

Just as there is no definite symptom complex in early malignancy of the lung, there are no distinguishing physical signs. In fact, small peripherally situated growths are notable for producing no abnormal signs. Stem bronchus tumors occluding but one of the lobular divisions may not produce abnormal physical signs. When a main bronchus or one of its lobar branches is involved, variable signs are produced depending upon the degree of obstruction and the presence or absence of secondary infection. It should, therefore, be emphasized that physical signs in early carcinoma of the lung are variable and unreliable. Their absence should not excuse the first doctor consulted in arranging for a chest x-ray. The presence of physical signs, suggesting congestion, consolidation, fluid, unresolved pneumonia, bronchitis, asthma or tuberculosis does not necessarily rule out malignancy. Any abnormal physical sign or any persistent symptoms relating to the chest call for further investigation.

CHEST ROENTGENOGRAMS ESSENTIAL

The structure of the lung creates an unique position for it among internal organs in respect to early detection of cancer. The density of the expanded lung is less than any other soft tissue organ. Therefore, it lends itself better than any internal organ to x-ray scrutiny. Minute lesions in peripheral portions of the lung field will cast a shadow. Small stem bronchus lesions whose direct shadow is obscured by trunk markings soon occlude a major bronchus or one of its subdivisions. Either lobar or lobular atelectasis results, which gives itself away on the chest film. In our experience, the x-ray revealed some abnormal shadow, either the discrete shadow of the tumor, an enlarged hilar shadow, or altered density due to atelectasis in 96 per cent of the cases. Discrete shadows of the tumor itself or massive atelectatic shadows are so striking that the doctor is usually induced to institute further investigation immediately.

It should be emphasized, however, that as more and more patients are studied by x-ray early in the course of the disease, the number of negative films or those which show but minor changes will increase. For example, a very small stem bronchus lesion which has not totally or partially occluded the bronchus may not produce either atelectasis or localized emphysema. In these cases, the x-ray would be negative. Occlusion of a branch bronchus and atelectasis of only a segment of a lobe may give a very confusing shadow or one that might be missed altogether. In Figures 1 and 2 are shown reproductions of x-rays which illustrate this point. In the first case, atelectasis of a portion of the right lower lobe might have been easily overlooked or confused with bronchiectasis. In the second case, the distribution of the tumor in the upper lobe simulated tuberculosis. The routine use of the x-ray in the examination of all patients with any chest symptoms is essential. The profession should profit from the experience gained in the findings of tuberculosis cases.

After many long years, it is now recognized that symptoms and physical signs in chest disease are not reliable. In order to find
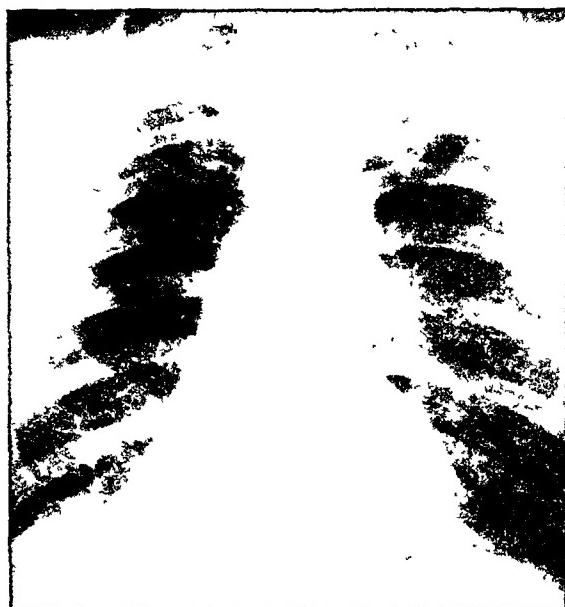
Fig. 1. Roentgenographic appearance of early stem bronchus carcinoma. Note slight increased density of lung field in right cardiophrenic region, and slight displacement of mediastinum and heart to that side. The lesion took origin in the bronchus of the right lower lobe causing only partial occlusion. Mr. A. F., age sixty-seven, was referred by Dr. J. McNamara, Taunton, Massachusetts. A chronic cough followed a chest cold seven months before admission. The sputum was at first scanty, then became more productive but was of a thin, clear, mucoid character, occasionally tinged with blood. Three months before admission the patient noticed a wheeze which appeared with increased activity. Bronchoscopic biopsy revealed an epidermoid carcinoma, Grade II. Exploratory thoracotomy was done on June 25, 1940, and tumor cells could not be demonstrated in the mediastinal glands. A right pneumonectomy was successfully performed. The patient was discharged on the twenty-sixth postoperative day after an uneventful convalescence.

minimal cases of tuberculosis, people who have had contact with known cases and selective groups of the population must be surveyed by x-ray. In the detection of pulmonary cancer, we are not confronted with screening large numbers of apparently healthy individuals, but efforts should be centered upon that portion of the population who complain of chronic chest symptoms, notably cough.

THE MAJORITY OF LESIONS CAN BE
SEEN AND BIOPSIED

Approximately three-fourths of all primary lung tumors which have been studied

was obtained in 71.6 per cent of the cases. In 127 verified cases studied by the author the diagnosis was first established by bronchoscopic biopsy in 61 per cent. (Fig. 3.) Gebauer has rightly pointed out that if
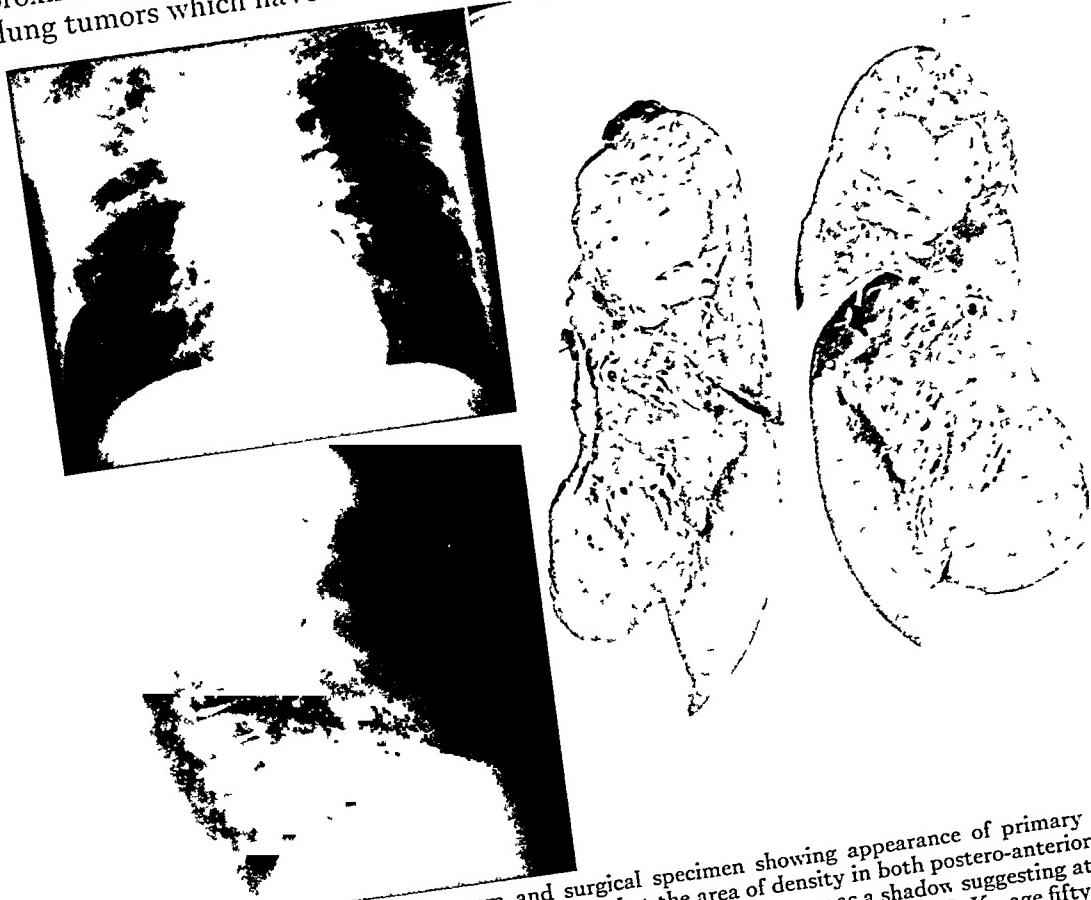
FIG. 2. Preoperative roentgenogram and surgical specimen showing appearance of primary carcinoma involving the right upper lobe. Note that the area of density in both postero-anterior and lateral exposures does not appear as a discrete rounded shadow or as a shadow suggesting atelectasis. The patient had been under treatment for tuberculosis at one time. Mr. S. K., age fifty-five, was referred by Dr. M. J. Stone, of Boston. Illness began with an attack of pneumonia six months previously. The patient was seriously ill for seventeen days, after which there was improvement, but there was persistent cough with yellowish green sputum. Bronchoscopic examination was negative. Exploratory thoracotomy was advised and carried out on December 13, 1940. A solid mass was palpated in the upper lobe. A single infracarinal lymph gland was enlarged and upon frozen section revealed an epidermoid carcinoma, Grade III. A right total pneumonectomy and dissection of mediastinal glands were successfully performed. The patient was discharged on January 24, 1941, as greatly improved. In May, 1941, upon follow-up examination, a persistent tachycardia was found. There was marked displacement of the mediastinum and heart to the right. A thorough search for recurrent disease was negative. On May 14, 1941, a right upper thoracoplasty was performed in order to correct cardiac displacement and prevent emphysema of the left lung. The patient left the hospital sixteen days later as improved.

clinically have been found to be within the range of vision bronchoscopically. In Gebauer's series[2] of more than 100 bronchoscopies, the lesion was seen in 72 per cent. In a consecutive series of sixty-seven cases studied by Betts[3] a positive biopsy

the time element is considered, a figure as low as 25 per cent for bronchoscopic inaccessibility is misleading as this includes a high proportion of late cases. When dealing with early lesions, perhaps 40 per cent will not be visible bronchoscopically. However,

the number of early stem bronchus lesions discovered will be in direct proportion to the frequency with which bronchoscopic

as an atelectatic shadow, enlarged hilar shadow, or opacity in the periphery of the lung field, bronchoscopy follows imme-

METHOD OF OBTAINING
TISSUE FOR DIAGNOSIS
127 VERIFIED CASES
PRIMARY CA. OF LUNG

61% — 78 CASES — BR-SCOPE
22% — 28 CASES — SURG-EXPL.
7% — 9 CASES — BIOP. MET
3% — 4 CASES — PLEURAL FLUID
I-CASE — ASPIR. TUMOR
5% — 7 CASES — AUTOPSY
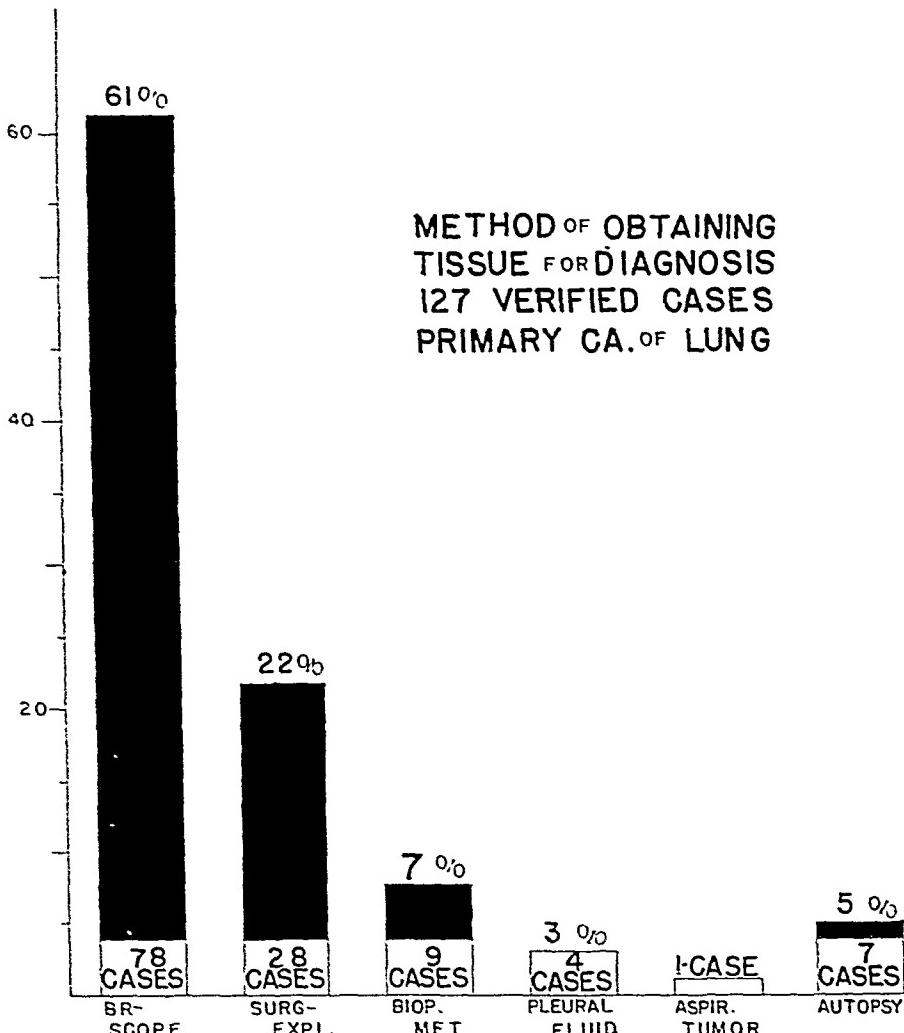
FIG. 3.

examination is carried out as a routine in all patients with bizarre chest complaints and abnormalities by x-ray.

diately. If the x-ray is negative and unexplained symptoms persist, bronchoscopy is still indicated.

SPEEDING UP MECHANISM OF EARLY DISCOVERY

An attempt has been made to show the important factors which will operate to speed up the mechanism of early discovery. A small tumor originating in the sensitive mucosa of one of the stem bronchi soon produces a chronic cough. This cough is an irritative, hacking and persistent one, which forces the patient to consult a doctor. The possibility of cancer is on the mind of the first doctor consulted. An x-ray is taken. If an abnormality is found such

THE SUSPECTED CASE—A SURGICAL PROBLEM

A positive bronchoscopic biopsy brings that patient up to the point of appraisal for operability and curative treatment. The patient suspected of having cancer, whose bronchoscopic examination has been negative, has been carried but half way along the path to early discovery and possible treatment. Failure to obtain a bronchoscopic biopsy should not be a cause of delay. The patient should not be permitted to slip into the hopeless group. The problem

for either the proved or suspected case at this point is still a surgical one. Many patients whose clinical investigations have been carried through this far strike a snag because opinions differ as to what the next step should be. Too often, the patient is advised to wait for absolute evidence of malignancy in order that surgery may in some way be avoided. While time is being used to wait for changes which make a diagnosis histologically positive, the patient may be robbed of his only opportunity for cure. Furthermore, many patients today with both proved and suspected malignancy are given x-ray therapy as the initial form of treatment. Many times, surgical treatment is not given consideration until after it has been demonstrated that the lesion has progressed in spite of radiation. Then, too often, nothing can be accomplished surgically. The criterion for the application of x-ray treatment should not be based on just the suspected or proved diagnosis of primary carcinoma of the lung. The true criterion for the application of x-ray treatment should be based on the establishment of the fact that the growth has spread beyond the lung, and is therefore, inoperable. In other words, the patient should be considered a surgical problem until inoperability has been established beyond a reasonable measure of doubt. Radiologists are almost in complete agreement that the great majority of primary bronchiogenic tumors are radio-resistant. In a recent report on the present state of radiation therapy, Dresser[4] stated: "Carcinoma of the bronchus is usually not responsive to radiation although there is an occasional rare exception." Graham[5] has stated, "I have been unable to find any incontrovertible evidence that up to the present time any case of primary bronchial carcinoma has been cured by radiation therapy."

Recently, Steiner[6] studied the microscopic effect of roentgenotherapy on twenty-one patients who had been treated and all studied at autopsy. Doses up to 5,000 roentgens did not destroy the cancer as judged by microscopic standards. Survival in the twenty-one patients treated was 11.9 months as compared to 10.5 months in fifty-three nontreated patients.

It is significant that not a single radiologist reporting experiences on radiation therapy of primary lung cancer recommends its use in operable cases. At the present state of our knowledge, radiation can be used with justice only for those patients in whom inoperability has been established. Patients with suspected or proved primary carcinoma of the lung are surgical problems until proved otherwise.

APPRAISAL FOR OPERABILITY

In appraising a proved case of cancer of the lung from the standpoint of surgical treatment, there are certain evidences that should be considered as positive, others as presumptive evidences of inoperability. Quite obviously, the greatest single fact which determines operability is the presence or absence of an extension of the tumor beyond the lung. Theoretically, absolute proof of metastatic disease can be given only when metastatic tissue is examined microscopically. Frequently, it is impossible to verify metastatic disease histologically. The following clinical signs appear most frequently in evidence of inoperability: (1) Frozen mediastinum as determined bronchoscopically; enlarged mediastinal glands without signs of fixation are not always involved in a metastatic process; (2) tracheal or contralateral bronchial involvement; (3) enlargement of lymph glands (cervical glands most frequently) proved to be involved by biopsy; (4) metastasis to the contralateral lung; (5) metastatic lesions to bones on unquestionable roentgen ray evidence or biopsy; (6) engorged veins of the neck and upper chest; (7) enlarged liver or jaundice; (8) advanced age; and (9) Complicating disease which within itself will prove to be fatal.

At one time, we were of the opinion that patients should not be accepted for surgical exploration if certain presumptive signs

were present. Paralysis of the diaphragm usually means infiltration of the phrenic nerve and widespread mediastinal involve-

ment. We have seen one such patient. Vocal cord paralysis also strongly suggests the possibility of mediastinal invasion.

New England Deaconess Hospital—General Division
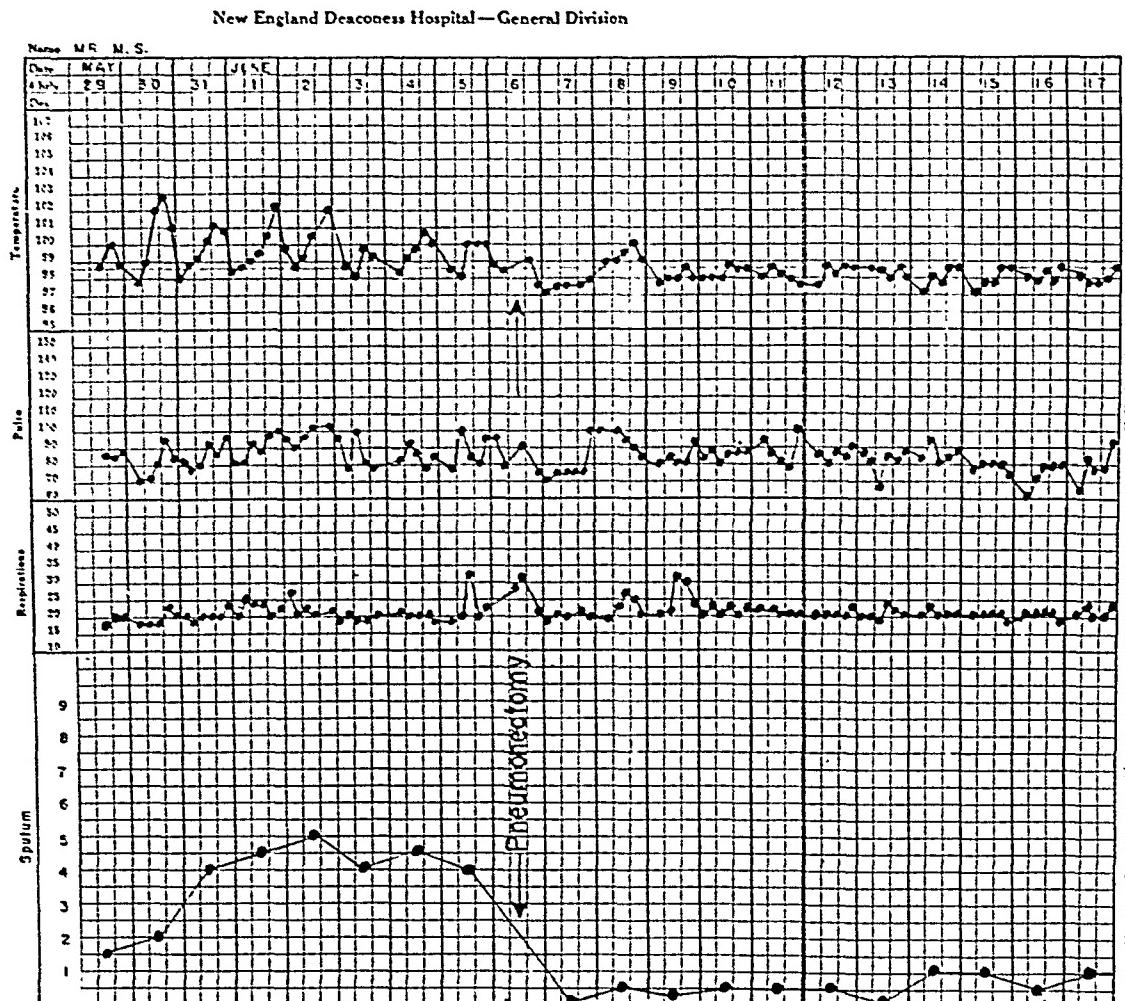
FIG. 4. Clinical chart showing record of temperature, pulse and respirations before and after total pneumonectomy. There was evidence of sepsis as well as a bronchial occluding cancer. Mr. M. S., age fifty-one, was referred by Dr. J. G. Adams of Salem, Massachusetts. A chronic cough developed four months previous to admission. The sputum was clear at first, later blood-streaked and mucopurulent. For two months the patient complained of profuse sweats, weakness and a weight loss of twenty pounds. Upon bronchoscopy an epidermoid carcinoma Grade II was found which partially occluded the left upper lobe bronchus. Considerable purulent material could be seen coming from beyond the lesion. The white blood count was 21,100. Left pneumonectomy was performed on June 6, 1941, and the patient was discharged from the hospital twenty-seven days later after a satisfactory convalescence.

ment. However, in one instance in which there was diaphragmatic paralysis, exploration was done and no mediastinal extension was found. Reservations must also be made in regard to clear pleural fluid free of tumor cells. Usually, a pleural effusion comes as a late manifestation of cancer after mediastinal lymphatics have been blocked. However, an occasional patient may have an effusion and still show upon exploration no evidence of mediastinal glandular involve-

Such a finding was encountered in three patients. All gave other evidences of inoperability and they were not explored.

Evidences of sepsis do not necessarily contraindicate pulmonary resection. Over one-half of all patients with primary carcinoma of the lung in our experience have shown effects of an associated lung infection. The toxic manifestations of a smoldering infection or suppuration distal to the occluding lesion may so prostrate the pa-
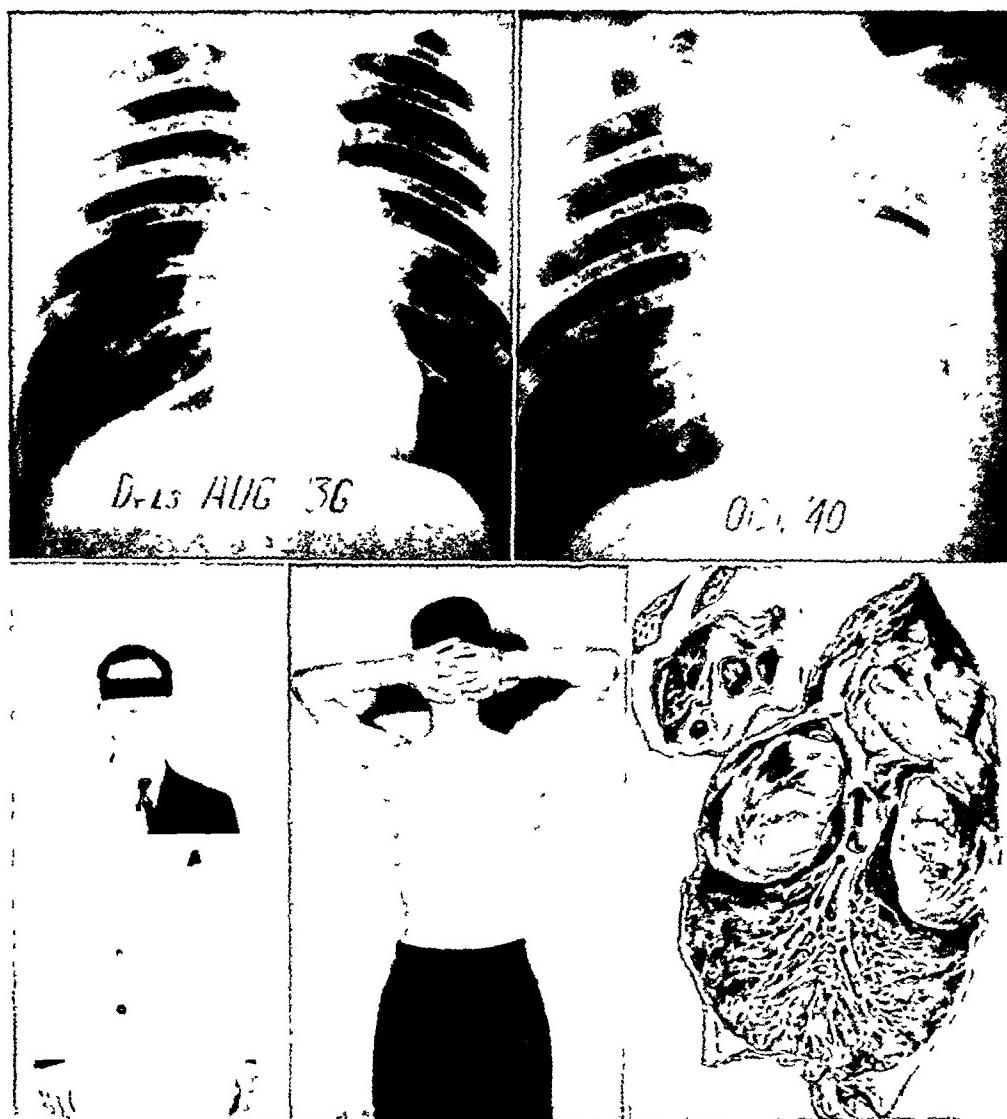
FIG. 5. Long standing disease which proved to be operable four years after onset of symptoms and five months after malignancy was first established. Note enlarged hilar shadow in 1936 film. Four years later there was a marked shift of the trachea to the left with an irregular density of the lung field. The photograph was taken six weeks after operation. Note freedom of deformity. A drawing of the sectional surgical specimen is shown. Note a well circumscribed mass which measured 6 by 4 by 4 cm. The small drawing shows the appearance of the left main stem bronchus which has been divided just above its first division in order to show the intrabronchial portion of the tumor. Dr. I. S., age forty-eight, was referred by Dr. P. G. C. Bishop, New York City. The patient had been having influenza-like episodes and attacks of bronchitis for a period of four years. The most recent attack occurred in March, 1940, with septic temperature for ten weeks and moderate amounts of purulent sputum. There was a loss of thirty-four pounds in weight. Bronchoscopy on June 7, 1940, revealed a tumor reported as malignant partially obstructing the left main bronchus. On November 1, 1941, an exploratory thoracotomy was performed. Mediastinal glands were found to be free of involvement. A left total pneumonectomy was carried out. The final pathological report was malignant infiltrating adenoma of bronchial origin. The patient was discharged forty days after operation following an uneventful convalescence.

tient that surgical intervention may be considered entirely out of the question. The procedure which removes the cancer-

patent ductus arteriosis or a large arteriovenous aneurysm. Ligation of the pulmonary artery and extirpation of the
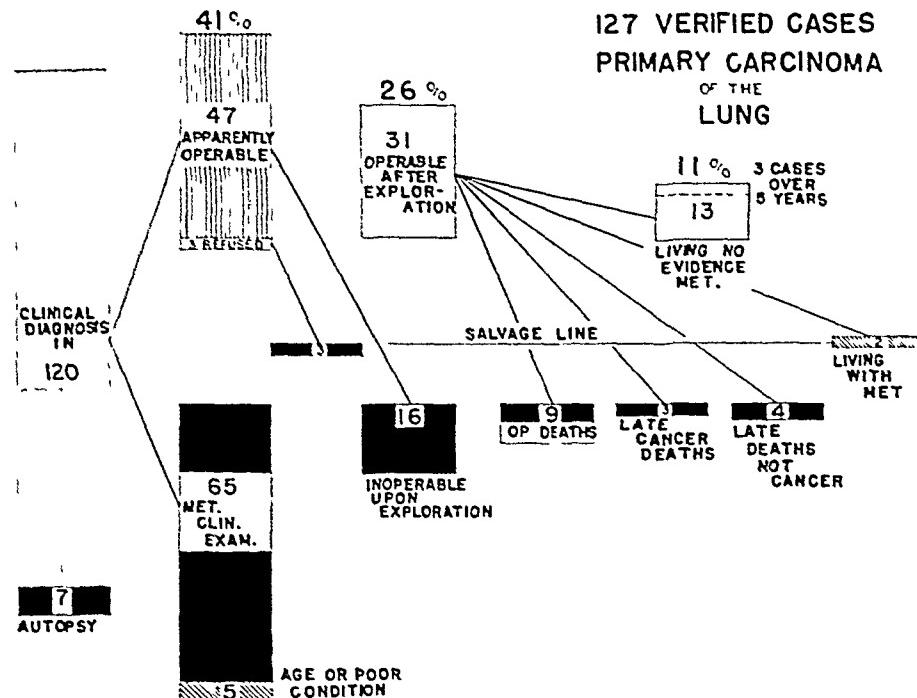
FIG. 6. A chart which shows the ultimate fate of 127 histologically verified cases of primary carcinoma of the lung. This represents all of the cases studied by the author between 1932 and March, 1941. Note the high incidence of clinical discovery. The percentage of operable cases compares favorably with operability of carcinoma of the stomach. Two of the late deaths caused by cancer occurred in patients treated by lobectomy. These cases antedated the now accepted use of pneumonectomy in the treatment of cancer. The four patients who died of other causes all received temporary benefit. It is significant that 11 per cent of the original group are living, well and free of metastatic disease.

bearing organ will also remove the septic reservoir. In Figure 4 is shown the clinical chart of a patient suffering from a bronchial occluding carcinoma with secondary infection. Immediately following surgical extirpation of the infected and cancer-bearing lung, the patient improved and signs of sepsis disappeared.

So-called signs of pulmonary insufficiency such as dyspnea, cyanosis or tachycardia are not bona fide evidences of inoperability. Such a situation is most frequently encountered when the growth has either completely or partially occluded a primary bronchus. The flow of blood through a nonventilated lung results in the return of considerable unoxygenated blood to the general circulation. The cardio-respiratory mechanism is greatly handicapped. The effect is similar to that of a

functionless lung increases the efficiency since all of the blood passes through a sound lung.

The duration of symptoms does not necessarily bear a relationship to operability. For example, in the case of Dr. I. S., symptoms of a bronchial occluding lesion had been present for four years. A bronchoscopic biopsy done five months previously had revealed an infiltrating adenoma which had become malignant. Although the history was a long one, there was no clinical evidence of metastasis. Thoracic exploration was carried out; mediastinal glands were not involved; and resection was successful. (Fig. 5.) A long history without clinical evidence of metastatic disease may actually be a favorable sign as it strongly suggests the presence of a slow-growing tumor or low-grade malignancy.

It is significant that in the author's series of cases, of 127 verified patients there were but five who were rejected for surgery because of too advanced age or too poor general condition. (Fig. 6.) There were but fourteen cases in the group of seventy-five unverified cases who were rejected for surgery. Many of these patients were unverified because the general condition or age of the patient did not justify bronchoscopic examination or surgical exploration in order to settle the diagnosis. These ratios do indicate that from a practical standpoint very few patients need be denied the benefits of surgical treatment because their general condition does not warrant thoracic exploration.

The problem of operability is not an easy one to settle. In dealing with a disease which is 100 per cent fatal without surgical excision, we are forced into the position of giving the patient the benefit of every doubt. The evidence that the tumor has spread beyond the lung must be above reasonable doubt. This question cannot be settled fairly by anyone who has not had an opportunity to follow such patients through a surgical program.

THE PLACE OF SURGICAL EXPLORATION

The problem presented by that group of patients in whom a presumptive diagnosis was made, but unverified by bronchoscopic biopsy, warrants special consideration. Great advances have been made in the surgical treatment of tumors of the abdomen, brain, and other organs simply because surgical exploration has been freely resorted to in doubtful cases. A clearcut policy should be formulated in regard to the suspected, yet unproved case of carcinoma of the lung. Tuttle and Womach[7] have expressed an opinion and it has been our own impression that the peripherally located tumors are more rapidly growing and more likely to metastasize at an early stage than stem bronchus lesions. This may be due in large measure to the policy of watchful waiting on the part of the first doctor consulted with the hope that time would furnish additional data and in that way clear up the diagnosis. If a patient with a peripheral lesion is going to be given a reasonable chance for cure, there must be a plan for immediate attack. If one waits for the growth to enlarge so that it can be seen bronchoscopically or for additional signs, these signs will most likely present themselves as evidences of extrapulmonary extension.

Attempts to settle the diagnosis by aspiration biopsy in early cases should be discouraged. It is illogical and unwise to resort to needle aspiration in operable cases. Regardless of the outcome of the aspiration, surgical exploration should be done. The positive case requires exploration for curative treatment. The negative case requires exploration for establishment of diagnosis and treatment. There remains a small minority with peripheral tumors showing evidence of extrapulmonary involvement in which aspiration biopsy may be used. In certain cases, however, a biopsy obtained through a small thoracotomy incision may be employed to double advantage. The open biopsy can be done with extreme safety and a larger specimen will prove to be more reliable from the standpoint of cellular arrangement and architecture.

The policy of recommending thoracic exploration in suspected cases of primary malignancy of the lung is sound and is the safest course to follow. For example, we found thirteen operable malignant lesions in a series of thirty suspected cases who were explored. (Fig. 7.) Nine of these patients were salvaged. Three have since died, leaving six who are living and free of evidences of metastatic disease. A watchful waiting plan would have meant death for all thirty. Prompt surgical exploration in future groups in whom the disease is suspected at an earlier stage by the first doctor consulted will raise the salvage rate considerably.

In addition to what one may do to prevent a death from cancer, there are other benefits in exploring doubtful cases.

If the lesion is not due to a cancer, there is a strong possibility that appropriate surgical treatment can be given. For example, nancy was ruled out and drainage of the areas resulted in cure. Three other extremely ill patients were thought to have
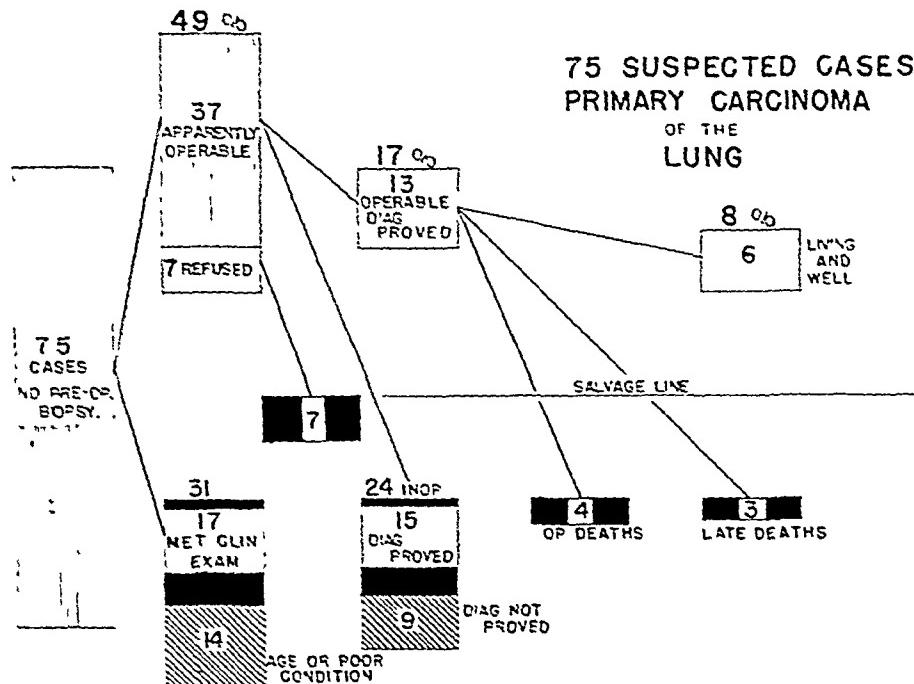
Fig. 7. A chart is shown which illustrates the salvage rate in a series of seventy-five patients suspected of having primary carcinoma of the lung. Of this group almost one-half showed no clinical evidence of an extension of the growth beyond the lung and surgical exploration was done. It is significant that of those cases explored 35 per cent proved to be operable. Twenty-eight of the above cases are also included in the chart shown in Figure 6, as the diagnosis was verified histologically after exploration.

it is at times impossible to differentiate clinically between a pulmonary abscess and a tumor. This is especially true when the onset has been insidious, when the lesion is fairly well circumscribed, and a fluid level is not seen by x-ray. One may proceed with a small thoracotomy opening which can be converted into a drainage tract should the lesion prove to be simply an abscess. Again, it is at times difficult to distinguish a small localized interlobar empyema from a tumor. Surgical treatment is indicated for either condition. For example, a small interlobar collection of purulent material of long-standing caused cough and hemoptysis in two of our cases. There was no elevation of temperature or white count. Bronchoscopy was negative and there was a lack of bronchial filling of the area after lipiodal. A tentative diagnosis of primary carcinoma of the bronchus was made and surgical exploration advised. In both cases, malig-

primary malignancy but were suffering from multiple abscess of the lung. In two of these patients, both the upper and lower lobes were involved and pneumonectomy was successfully performed and was curative. In a third case, Miss B. L., a mass three inches in diameter was found in the left lower lobe which, after lobectomy, proved to be a chronic multilocular abscess. These cases are cited to illustrate the importance of attacking questionable cases in a straightforward surgical way. The diagnosis can be settled and curative treatment can be instituted.

CONCLUSIONS

Carcinoma of the lung has become of vital concern to every practicing physician for four good reasons: (1) Malignancy originating in the lung is near the top of the list as a cause of cancer deaths. (2) It is curable in its early stages. (3) Methods are

available for detecting early cases. (4) There is reason to believe that the majority of patients consult a doctor at a time when the lesion is still in an operable stage.

Emphasis has been placed upon practical measures by which all doctors can contribute in the control of this disease: (1) Methods which will aid in speeding up the mechanism of early discovery have been outlined. (2) A plea has been made for an agreement on management for all suspected or proved cases with special reference to radiation versus surgery. (3) Criteria of inoperability have been discussed. (4) In patients presenting presumptive evidence of cancer without bronchoscopic visualization, the value of surgical exploration has been emphasized.

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WHEN one is confronted by a simple colloid goiter of some age the possibilities may exist that it is doing one of three things: nothing: becoming toxic; or degenerating. When the goiter is doing nothing it speaks the language of a small boy; it has not yet done anything that can be discovered. One may be pretty sure a colloid goiter is already mischief bent.

DIFFERENTIAL DIAGNOSIS OF PRIMARY AND METASTATIC MALIGNANCY OF THE LUNG*

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PRIMARY carcinoma of the lung has been brought into the fold of curable cancers. More and more frequently the problem of differentiating growths which have originated in the lung from a "solitary" pulmonary metastasis must be solved.

Primary tumors of the lung can be conveniently separated as to location into central and peripheral groups. The former have their origin in one of the larger bronchi. These lesions can be seen and biopsied bronchoscopically. Tumors of the central group soon occlude a large bronchus with resulting atelectasis, which may be suspected by physical examination and will be detected roentgenologically. Differential diagnosis is not difficult. Peripheral tumors arise in smaller bronchi and, therefore, are not visible at bronchoscopy. Peripheral tumors do not occlude large bronchi in the early stages so that signs of atelectasis are lacking. Unless the tumor is large they produce no abnormal physical signs. On roentgenological examination they usually present themselves as more or less rounded discrete masses, but many times the shadow may be confused with other conditions.

The differential diagnosis of peripheral lesions is too often deferred until the growth produces marked symptoms and gross disturbances with involvement of pleura or distant metastasis. If we wait until the gross changes are unmistakable, we shall make no mistakes in diagnosis, perform absolutely no unnecessary operations and cure practically no patients. Our diagnostic accuracy and ultimate mortality will be close to 100 per cent.

It is the purpose of this paper to discuss the differential points of the peripheral primary lung cancer and solitary metastasis from an extra pulmonary primary lesion.

THE LUNG AS A FILTER FOR TUMOR METASTASIS

The lung is a mirror of the human body for cancer. Malignant growths, when considered collectively, cause death by pulmonary metastasis in 30 per cent. In growths originating in organs not drained by the portal system, the incident is even higher, 36 per cent. Thus, by including the 10 per cent of deaths which are due to primary carcinoma of the lung, we obtain a view of 40 to 46 per cent of all the cancers of the body by looking into this mirror.

It should be made clear that involvement of tissues by contiguity, either from primary or secondary growths, is not metastasis. Only emboli which have arisen from the primary growth as detached, transported fragments of that tumor are entitled to be called metastasis. Pulmonary metastasis may be solitary but is usually multiple and bilateral. In the latter case, the patient is obviously beyond the range of surgical aid.

The differential diagnosis is concerned primarily between the primary peripheral and the solitary pulmonary growths. There is evidence from postmortem examination that solitary metastasis occurs in some instances. Lenke[1] reports three cases with a single deposit in the lung; two were from a hypernephroma of the kidney; the other was a chorion epithelioma. Brandt, Pirchan and Sikl[2] have reported cases of renal carcinoma with a single

deposit in the lung as the only metastasis. Barney and Churchill[3] reported the successful removal of a "solitary" pulmonary metastasis from a primary kidney tumor. The patient was alive and well after five years.

In cases such as these, are we to assume that a solitary tumor embolus was discharged from the primary growth and that it finally reached a fortuitous destination? Or are we to assume rather that multiple emboli were discharged from the primary growth but that only one of these survived to grow in some favorable situation? Tumor embolism is not metastasis. Many neoplastic emboli perish or remain sterile in the new sites of arrest. The "seed" has failed to germinate because the "soil" is poor.

Tumor emboli to the lung arise from tumor invasion of the systemic veins and metastatic growths in the lungs arise from these malignant emboli carried in the pulmonary arteries to be arrested in the smaller vessels. The first minute vessels encountered by emboli liberated from the other organs are the pulmonary arterioles and capillaries; and most systemic venous emboli suffer arrest in this great filter. Emboli apparently arise in periodic showers. In some cases multiple growths are all of similar size, suggesting a simultaneous origin in one shower of emboli; in other cases growths of all sizes may be present, indicating embolic inoculations of different ages.

CLINICAL CONSIDERATIONS

The diagnosis of either primary peripheral or "solitary" metastasis of the lung must be based on the summation of all the clinical data. A careful search should be made for a possible primary site elsewhere. Complete kidney and gastrointestinal roentgenological studies should be made. The absence of a positive extrapulmonary primary site throws the weight of evidence in favor of a primary pulmonary tumor. Although absolute differentiation between the two lesions is many times impossible, certain clues, which may be of help, are summarized in the table below:

DIFFERENTIATION OF PRIMARY PERIPHERAL AND META-STATIC PULMONARY CARCINOMA

Primary Peripheral Carcinoma	Common to Both	Metastatic Carcinoma
Symptoms		
Hemoptysis is fairly common.	There may be none whatever. Pain or discomfort of the chest may be present due to peripheral or sub-pleural location. There is little difference in the frequency or character of cough.	Hemoptysis is uncommon.
Signs		
	There may be none. These are variable depending on size and location of tumor.	
X-ray		
The lesion is single... The lesion is unilateral. The lesion is more often in the upper lung fields. Cavitation is more frequent.		The lesion is usually multiple. The lesion is usually bilateral. The lesion is apt to be in the lower lung fields. Cavitation is infrequent
Bronchoscopy		
	Both types are usually beyond bronchoscopic range	

Methods other than bronchoscopy for obtaining tumor cells for verification of diagnosis are of little practical value in operative lesions.

A study of the cytology of pleural fluid when present is important in obtaining a diagnosis. It is a late sign, however, and evidence of inoperability.

We have examined the sputum carefully in our cases and have occasionally recovered tumor cells in far advanced cases. We have not been able to determine accurately the type of tumor from such studies.

Transpleural aspiration is highly recommended by Craver.[4] This method is useful only in cases which are obviously inoper-

able. To the thoracic surgeon it is a useless procedure for if the biopsy is positive in a suspected case without clinical evidence of

The patient stated that she had felt well and continued to work until one year prior to admission. Quite insidiously, in the spring of 1937,

Fig. 1. Case 1. Postero-anterior x-rays of the chest are shown. A, shows diffuse haziness in lower left lung field; B, bronchogram revealing blockage of lingular branch of the left upper lobe.

metastasis, exploratory thoracotomy is indicated; and if the biopsy is negative in the same type of case, the same exploration is still the next step in its management.

The following case reports, illustrating many of the points described in regard to differentiating between primary and secondary malignancy, are printed in detail. Both patients are alive and well today because the problem of differential diagnosis was settled by exploratory thoracotomy.

The following case history relates the course of a patient who had a resection of the cecum for adenocarcinoma. She remained well for four years. Then she developed respiratory symptoms and was found to have a shadow in the chest film suspicious of malignancy. This patient is at the present time enjoying good health without evidence of disease, three years after pneumonectomy.

CASE 1. Miss S. S., a fifty-three year old, single, Syrian woman, was referred by Dr. Jacob Auslander of New York City. She was admitted to the New England Deaconess Hospital on the service of Dr. Richard H. Overholt on April 8, 1938, with a chief complaint of cough and hemoptysis of one year's duration. The one significant fact in the past history was that the cecum had been resected for neoplasm four years previously by Dr. A. A. Berg.

she began to raise small amounts of blood, associated with a slight cough. Several times a week this event was repeated. Shortly thereafter, a vague sense of discomfort in the left lower anterior portion of her chest was noted. She went to a doctor and a chest x-ray was taken which disclosed an area of increased density in the left lower lung field. The patient continued coughing and raising small amounts of blood without the development of additional symptoms. Concern about the continued hemoptysis led her to seek further investigation and Dr. Auslander was consulted.

Physical examination revealed a well developed, obese woman of fifty-three years. The only positive findings were diminished breath sounds over the midaxillary area of the left chest. A well healed, right rectus scar was present. Rectal and pelvic examinations showed no abnormality.

Roentgenographic examination of the chest revealed an area of increased density in the anterior portion of the left lower lung field. (Fig. 1.)

Bronchoscopic inspection of the trachea and major bronchi showed no abnormality. A very good visualization was obtained of the left upper lobe bronchus, it being possible to see up the bronchus as far as a spur between its next division, but no evidence of new growth or other abnormality was noted. Under fluoroscopic control, bronchographic studies of the left bronchi were made. An occlusion of the lingular branch of the left upper lobe bronchus

about 1 cm. distal to its origin from the left upper lobe bronchus was found.

Skeletal roentgenograms were negative for evidence of metastatic disease. No pathological

mottled gray, yellow, red and black. Bronchi and vessels appear negative at hilus. Microscopic diagnosis: Adenocarcinoma, probably metastatic from gastrointestinal tract."
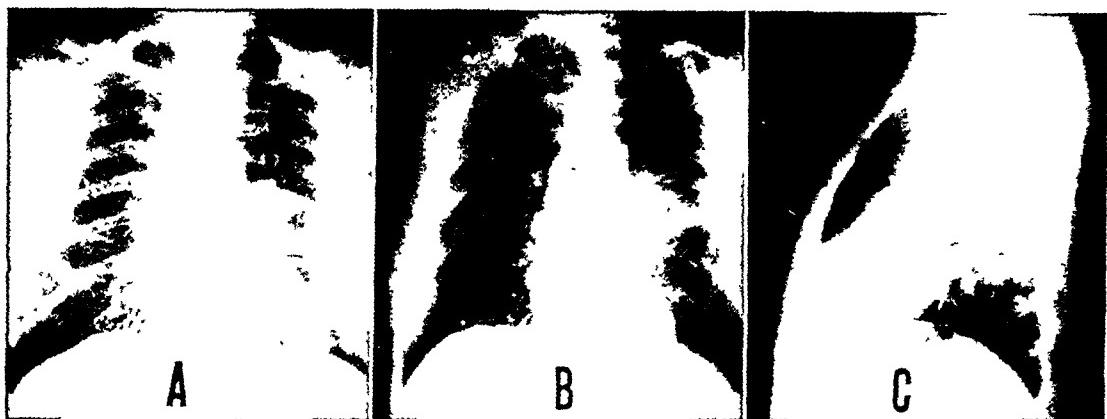

FIG. 2. Case II. A and B, postero-anterior and left anterior oblique x-rays of the chest show the opaque, irregular shadow at the left hilum; C, left lateral x-ray reveals the suspected tumor to be posterior.

condition of the kidney was revealed by pyelogram. A barium enema showed no evidence of local recurrence. The pathological report of the previously resected cecum was secured. It reported adenocarcinoma of the cecum without evidence of lymph-node metastases. Although the probability was held that the nodule in the left lung was a late metastasis from the cecum, it was impossible to rule out a peripheral primary carcinoma; and due to the fact that serial x-rays showed that a definite increase in its size had taken place in the last four months, an exploratory thoracotomy was thought advisable.

Pneumothorax was then instituted on the left side and maintained for three weeks. On April 11, 1938, an exploratory thoracotomy was performed under cyclopropane intratracheal anesthesia. The tumor presented itself in the lower part of the upper lobe as a firm well circumscribed mass which puckered the lung tissue and was about one and one-half inches in diameter. The parietal pleura was not involved. A frozen section of a gland from the hilum showed no evidence of malignancy. Pneumonectomy was performed, with individual dissection and ligation of the hilar structures.

The pathological report of the tumor removed from the lung was as follows:

"Left lung—weight 330 gms. Lower portion of upper lobe contains a firm nodule 6 cm. in greatest diameter with a puckered area 4 cm. in diameter on surface. Cut surface of nodule is

The patient's postoperative course was uneventful and she was discharged from the hospital on May 10, 1938, twenty-one days after operation. The patient was last examined on May 16, 1941, three years after pneumonectomy. She reported that she had been enjoying good health. There were no symptoms referable to the chest or abdomen. She was employed as a saleslady. Physical examination revealed no signs of metastatic disease.

CASE II. Mr. N. W., a fifty-five year old, retired, widowed business man was referred by Dr. Charles W. McClure of Boston. He entered the New England Deaconess Hospital on January 23, 1941, with a chief complaint of nausea, vomiting and anorexia of one year's duration. Family history and past history were negative.

The present illness dated to the sudden death of his wife one year previously. Following this, he noted anorexia and later nausea and vomiting. There had been frequent and excessive use of alcoholic beverages. After obtaining no relief from various medicines, a gastrointestinal roentgenographic examination was advised. While these x-ray studies were being carried out, an abnormality in the left lung was noted. Chest symptoms were not present except for a slight cough of fifteen years' duration, attributed to cigarettes. Although the patient had no urinary symptoms, he had been informed one week previously by his physician that blood was found in the urine.

Physical examination revealed a well developed and well nourished man with evidence of slight weight loss. A few crackling rales were noted in the left mid chest posteriorly, and transient moist rales at the right base which cleared after coughing. The heart was within normal limits; the blood pressure was 160/88. The remainder of the physical examination was entirely negative.

Laboratory examinations revealed the red blood count to be 3,540,000; hemoglobin, 68 per cent; white blood count, 10,300; nonprotein nitrogen 30 mg. per cent. The blood Hinton was negative. The urine was grossly bloody and the sediment was loaded with red blood cells.

Complete urinary studies were made by Dr. Harvard Crabtree, and ureteral catheterization showed the blood to be coming from both kidneys. Retrograde pyelograms revealed no etiological factor. The urological consultant suggested a diagnosis of idiopathic hematuria.

X-ray examination of the chest showed an infiltrative lesion extending out in the region of the left hilum suggestive of neoplasm. (Fig. 2.)

Bronchoscopic examination was negative except for a slightly granular appearance of the left main stem bronchus at the level of the upper lobe orifice. A biopsy showed no evidence of malignancy.

After a preliminary left pneumothorax was established, the chest was explored on February 13, 1941. A tumor mass about the size of a lemon was encountered in the left lower lobe. Several lymph-nodes were removed which were negative on frozen section. A one stage left pneumonectomy was carried out. The pathological report was as follows:

"Specimen consists of four soft, dark gray nodes. Also a left lung weighing 370 grams. The upper lobe is partially subdivided into two lobes. The pleural surface is mottled light pink and dark gray. The substance of the lung is crepitant throughout except for an intrinsic mass roughly 6 cm. in diameter which involves the apex of the lower lobe and hilus and is firmly bound to the main bronchus. There are several large, only slightly firm anthracotic nodes in the hilus. Microscopic diagnosis: Epidermoid carcinoma, Grade I. Five lymph nodes negative."

The patient's convalescence was quite satisfactory although he developed a transient auricular fibrillation on the third postoperative day. He was discharged on January 31, 1941, forty-five days after operation. When last seen on June 27, 1941, he was feeling perfectly well and was asymptomatic. Evidence of metastatic disease could not be found.

DISCUSSION

The chest x-rays in both these cases lead one to suspect carcinoma strongly, but a verified diagnosis could not be made. How shall we handle these cases in which we have presumptive evidence of malignant disease of the lung, but in which the clinical evidence is not conclusive? Shall we temporize and await developments, trusting that the condition is not malignant? Shall we irradiate prophylactically, or shall we explore the suspicious lung? If we temporise, then we have made Time the executioner again rather than the great healer. We believe that preoperative irradiation is not advisable in those cases in which the diagnosis is uncertain and in which there is demonstrable evidence that extrapulmonary extension of a possible malignant process has taken place. In these cases one wishes to see things as they are. The suspected early tumor is probably small. If it is also liquefied or partly destroyed by irradiation, the tumor becomes much more difficult to recognize. The concurrent changes in the surrounding tissue then present a very confusing picture. Tissue cannot be counted on to heal properly when its vascularity has been greatly impaired by radiation.

It therefore seems best that when the evidence points to the probable diagnosis of lung tumor, even though it is not conclusive, the proper treatment is immediate exploration of the suspected lung, just as an exploratory laparotomy is indicated in a suspicious lesion in the stomach or bowel when the presence of malignancy cannot be excluded. One might say that it is unscientific and unjustified to explore all cases of suspected peripheral tumor; yet it is even more unfortunate to withhold indicated treatment if the patient has an early

primary lesion. "Solitary" pulmonary metastasis does occur and may be indistinguishable from a primary growth. If the primary malignancy has been removed and a solitary lung lesion is the only sign of metastatic disease, resection of the lung and metastatic nodule appears to be justifiable.

CONCLUSIONS

Difficulties arise in differentiating primary peripheral cancers of the lung from solitary metastatic lesions. Both lesions are beyond the range of the bronchoscope. If an exhaustive search for a primary extrapulmonary tumor is negative, evidence will weigh heavily in favor of primary lung cancer. These patients should receive the benefit of an exploratory thoracotomy.

If a suspicious solitary lung lesion is discovered at a reasonable interval of time after removal of a primary tumor elsewhere and the lung findings present the only evidence of a possible metastatic lesion, exploratory thoracotomy is indicated.

Cases illustrating these two principles have been cited. In both cases exploratory thoracotomy settled a doubtful diagnosis and led to treatment that promises to be curative.

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BRONCHIAL ADENOMA*

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THE necessity for separating bronchial adenoma from other tumors of the lung has existed since 1932[1] when they first became clinically recognizable. Accurate diagnosis goes hand in hand with development of adequate therapy. The treatment of bronchial adenoma is different from the treatment of cancer of the lung, or tuberculosis, or bronchiectasis, with which adenoma is frequently confused. Treatment must be based upon sound knowledge of the life history of the tumor as well as an accurate diagnosis. The accurate diagnosis of bronchial adenoma should include more than the discovery of its mere presence. It ought to indicate the exact location with reference to the lobar bronchi, the presence or absence of bronchial obstruction, the size, shape and extent of the extrabronchial tumor, the nature of the endobronchial portion, its relations to the inner bronchial wall, and, finally, the condition of the distal lung. To obtain this information in any patient with a polypoid bronchial tumor, a broad knowledge of all the features of bronchial adenoma is essential.

It is the purpose of this paper to set forth a concise description of bronchial adenoma in all its phases.

Our concepts are based upon a 100 per cent follow-up of nineteen cases (some of which have a clinical course of twenty to twenty-five years) from the Thoracic Surgery Clinic at the University of California Hospital, and an additional forty cases personally reviewed in various clinics of this country. Probably all the protean manifestations and the natural history of bronchial adenoma have not been covered in the study of this group of cases. Newer knowledge may change our future concepts.

However, when we undertook this study we had no preconceived ideas or hypotheses. Our conclusions were forced upon us from the careful study of the cases including a correlation of their history, diagnosis, treatment and pathological findings.[2-6]

The history and evolution of the separation of bronchial adenoma from carcinoma may be divided into three periods: The first began in 1882 with the publication of Mueller's case,[7] and ended in 1932 with the report on bronchial adenoma by Wessler and Rabin.[1] This period may be described as the postmortem recognition of bronchial adenoma.[8-14] The second period, from 1932 until 1938, may be called the period of clinical recognition and treatment. During this period, several important papers appeared.[15-19] Since 1938 until the present time may be called the period of development of rational therapy based upon new knowledge of the natural and therapeutic life histories of these tumors.

As one reviews the literature, he is struck by the confusion, particularly regarding the terminology applied to what is apparently the same tumor which we now term bronchial adenoma. Ephraim,[20] in 1911, termed these tumors sarcoma of alveolar pattern; Kreglinger[10] (1913), cylindrical cell carcinoma; Geipel[14] (1931), basal cell cancer; Wessler[1] (1932), benign bronchial adenomata; Kernan[15] (1935), carcinoids; Moersch[21] (1935), adenocarcinomas; Clerf and Crawford[22] (1936), benign glandular tumors; Zamora and Schuster[23] (1937), vascular adenoma; Welt and Weinstein[24] (1937), endotheliomas, and finally Womack and Graham[17] (1938), mixed tumors of the lung.

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DURATION AND SEX

The age of the patient at the onset of symptoms of adenoma is strikingly different from that of patients with carcinoma. In our nineteen cases, twelve or 63 per cent had symptoms before the age of forty in contrast to only 11 per cent in Brunn's large series of carcinomas.

The distribution by sex is likewise in marked contrast to that of carcinoma. In our nineteen cases of adenoma, twelve or 63 per cent were female, whereas only 9 per cent of 111 cases of our carcinoma were females.

In prognosis and duration of life, also, patients with adenoma present a marked contrast to those with carcinoma. If all cases of probable adenoma which have been reported as carcinoma are excluded, only a small percentage of "five year cures" of bronchial carcinoma remain. Notable among these is Graham's first case, now in its ninth year. On the other hand, the prognosis for patients with adenomas is very good, and many "five year cures" have been reported. In our series, for example, all but three, or sixteen patients (84 per cent) lived more than three years after the onset of symptoms, fourteen (74 per cent) more than five years and seven (37 per cent) more than ten years. These figures are noteworthy since in Brunn's series of carcinomas only 4 per cent of 207 patients survived three years or longer.

PATHOGENESIS

The pathogenesis of all polypoid bronchial tumors leaves much to be desired. One can make few statements that can be proved or that are founded on fact. Many authors have given names to these tumors which have suggested their origin from a specific cell or tissue. It has become fashionable these days to assume the origin of cancer of the lung and, in fact, of all epithelial bronchial tumors to be from the reserve cell found in the bronchial wall. According to this view then, bronchial adenoma should arise from the reserve cell. If we accept Womack's and Graham's interpretation, we must postulate that bronchial epithelial tumors have an origin in more than one type of cell from vestigial fetal lung buds; and so this mixed origin gives rise to the production of mixed tissues seen in the adult tumor where bone and cartilage, along with epithelial patterns, are not uncommon. If we accept the work of Allen, it would not be necessary to assume the origin from mixed fetal tissues, because he says that adult epithelial cells may differentiate into cartilage or bone under stimuli of repeated trauma, infection and local change within the tumors. Kramer and Som have called attention to this process of differentiation and believe it occurs in bronchial adenomas. According to Womack and Graham's concept, adenomas should be regarded as potentially malignant, and the discovery of rare mediastinal lymph-node metastases is evidence in favor of this viewpoint. According to Bremer, bronchial adenoma represents residual fetal lung. Welt and Weinstein, and Tudor Edwards, argue for endothelial origin. Reissner, and Wessler and Rabin believe that tumors arise from the bronchial mucous glands or from their ducts. Our own concepts are that bronchial adenomas arise from the mucous glands and their ducts which, being mixed glands, are apt to have varying patterns, and which in general follow the behavior of adenomatous tumors arising from these glands elsewhere in the body. Bone and cartilage formation is probably the result of de-differentiation of adult tumor cells.

Regardless of the tissue of origin, the high incidence in women and the occurrence of pulmonary hemorrhage with the menstrual bleeding suggests that circulating hormones may bear some relation to the pathogenesis of these tumors; but this is highly conjectural.

GROSS PATHOLOGY

Bronchial adenoma is almost always connected with a large bronchus, usually has an endobronchial portion obstructing this

bronchus and, in approximately 90 per cent of cases, has an extrabronchial extension (Fig. 1A and B) frequently larger than the endobronchial portion. The endobronchial portion is covered by mucosa which may undergo a complete metaplasia into squamous cell type (Fig. 2) and may have branches of the bronchial vessels coursing over its surface. Beneath this mucosa, whether metaplasia has taken place or not, is a layer of fibrous tissue, usually dense hyaline connective tissue but sometimes a loose, delicate, many-layered fibrous tissue. Extensions from this fibrous capsule subdivide the tumor and give to the peripheral surface a bosselated appearance, while the cut surface thus receives a papillary pattern. When bone is present throughout the tumor, the otherwise smooth surface becomes rough and the projecting spicules are readily felt by the palpating finger. The extrabronchial portions projecting into the mediastinum or surrounding lung are also encapsulated, but of course their capsule is not covered with mucosa. At times a tremendous endobronchial growth of the tumors thins the bronchial rings and causes them to be dis-

Fig. 1. A. and B, morphology of bronchial adenoma.

placed and surrounded by tumor. Although the bronchial cartilage is not invaded, it may become atrophic. Because of the

HISTOPATHOLOGY

The cell type (Figs. 2 and 3) which characterizes bronchial adenoma is a small
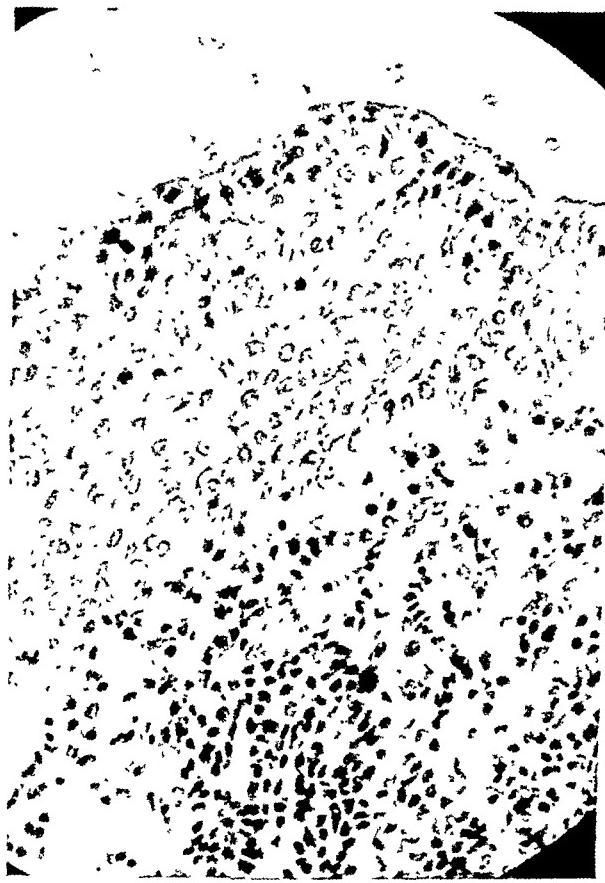
FIG. 2. Case VI. H. G. Bronchoscopic biopsy, 1933. Shows metaplasia of the mucosa overlying a tumor. Note the pyknotic nuclei and the indefinite patterns of the small tumor cells underlying the mucosa. × 120.

atrophy and distention of the bronchial wall, it is often difficult to determine whether all the tumor is within the bronchus or has pressed its way out into the lung or mediastinum. The location in a distended large bronchus causes the pulmonary artery and veins to be stretched over the tumors and the usual hilar relations become somewhat distorted. Longstanding pulmonary suppuration enlarges the mediastinal lymph-nodes but they contain no tumor in a careful study of our cases.*

* In one patient operated upon by Dr. Edwin Churchill and demonstrated by Dr. Castleman, there was contiguous extension into one mediastinal lymph-node; and a second similar case was recently shown us by Dr. David Wood.

cuboidal or polygonal cell, which is uniform, with an oval or round, darkly staining nucleus. The chromatin is finely divided and there are no large nuclei. Mitotic figures are absent. There is a tendency for the cells to be grouped and to form several types of patterns. These may be distinguished as alveolar, columnar, medullary, acinar, mosaic and angiomatoid patterns. A delicate reticular stroma runs through the tumor, encompasses the groups of cells and is contiguous with the fibrous tissue capsule. At times the stroma surrounds large vascular spaces. Particularly at the periphery of the endobronchial portion of the tumor, vascularity is apt to be prominent. In some cases the histologic

pattern is uniform throughout the whole tumor but in others the patterns vary a great deal in different parts of the tumor. The stroma may vary from a well developed, reticular, delicate network to a thickened or hyalinized framework which may contain large vascular spaces. In the fibrous tissue capsules, groups of tumor cells may be seen. Bone and cartilage are present in some tumors. (Fig. 3F.)

Microscopic diagnosis of adenoma from the material removed at bronchoscopic biopsy is not always easy unless the tissue shows characteristic patterns. Squamous cell carcinoma, because of squamous cell metaplasia present on the mucosal surface, angioma or angio-endothelioma because of the vascularity at the periphery of the tumor, inflammatory tissue when the epithelial surface has been altered by infection or trauma, small cell carcinoma when the biopsy has been crushed or the cells seen are not arranged in characteristic patterns—any of these may be diagnosed instead of adenoma. However, once typical patterns are obtained the diagnosis is easy to a pathologist familiar with these tumors.

COMPLICATIONS

Complications of these bronchial tumors are important since they frequently bring about the entire presenting clinical picture, and one is apt to discover patients being treated for pneumonia, bronchiectasis, lung abscess or empyema when adenoma is the hidden primary condition. If the bronchial obstruction is located in the stem bronchus, complete atelectasis will result sooner or later with infection in all the lobes of the obstructed lung. Anaerobic infection produces virulent, putrid abscesses, but more commonly nonputrid bronchiectasis is present. The pleural cavity is usually involved due to the contiguous extension from infection of the lungs, so that bronchopleural fistula, difficult to close, often accompanies the empyema. It is of interest that none of our patients has developed tuberculosis —an observation which may be related

to the collapsed condition of the lung.* Rarely, large cystic dilatations filled with blood or straw-colored fluid occur in the lung. (Fig. 4A and B.) Pneumococcic infections occur in the obstructed lobe and give rise to a typical lobar pneumonia.

NATURAL AND THERAPEUTIC LIFE HISTORY

The natural growth of these tumors is slow. They take as long as twenty years to reach the size of a grapefruit. They invade by pressure atrophy and not by the true invasiveness exhibited by malignant, metastasizing tumors. By so doing, the bronchial wall is "penetrated." The extrabronchial portion grows to a larger size than the endobronchial portion. Extrathoracic metastases are unknown; mediastinal lymph-node metastases are exceedingly rare. Mediastinal encroachment may occur but phrenic paralysis, Horner's syndrome, or vena cava obstruction are not found. Growth of the tumors after various therapeutic procedures again indicates the very low growth potential of bronchial adenoma. After bronchoscopic removal, "recurrence" may be discovered as long as four to twelve years later. After biopsy through the bronchoscope, the wounds heal quickly. Transsection of the tumor during lobectomy has not produced untoward results. There is no evidence that the various surgical manipulations produced more rapid growth, metastasis or implantation.

Contrary opinions have been expressed as to the invasiveness and metastasizing capacity of adenomas. In our experience, whenever metastases have occurred in patients with similar clinical histories but doubtful histopathology of biopsy material, postmortem examination has shown the growth not to be adenoma but to belong to the lymphangio-endothelial sarcomas, leiomyosarcomas, slowly growing carcinomas or other as yet unclassified groups.[4]

* In a recent case of slowly growing adenocarcinoma (possibly adenoma) published by Gebauer, an acute tuberculous abscess occurred in the obstructed lower lobe.
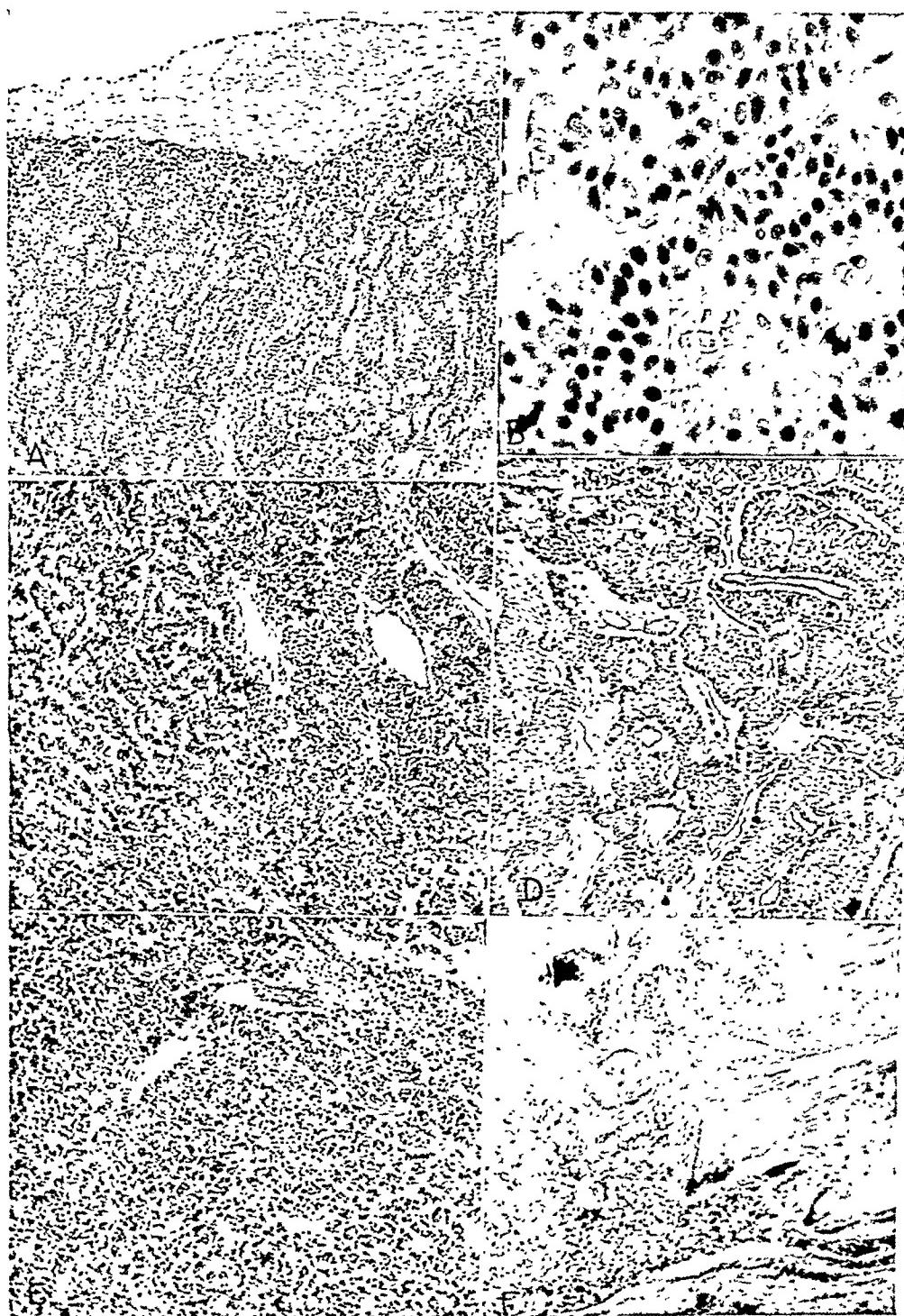
FIG. 3. Typical patterns obtained from postmortem or pulmonary resection specimens. A, Case
XIV. G. D. Columns of uniform cells extending toward the fibrous tissue capsule. The bronchial
mucosa has been denuded. Note the relative absence of pyknotic nuclei. × 120. B, Case XIV.
G. D. Section of the surgical specimen showing both cylindromatous and alveolar patterns.
× 50. C, Case IV. H. L. Section of the extrabronchial tumor. Note two different patterns on the
same section. D, Case IV. H. L. Note the mosaic pattern made up of large groups of cells and
prominent vascular stroma. This section of the tumor appears markedly different from that seen
in C. × 120. E, Case I. I. K. Note the mosaic pattern made up of small groups of cells. This
pattern was uniform throughout all the sections made of this tumor. × 120. F, Case X. F. J.
Formation of osteoid tissue in extrabronchial portion of the tumor. × 120. (From Goldman,
Alfred and Stephens, H. B. Polypoid bronchial tumors with special reference to bronchial
adenoma. *J. Thoracic Surg.*, 10: 335, 1941.)

SYMPTOMS AND CLINICAL COURSE

Symptoms are related to location, vascularity and slow growth. Location of the adenoma in a major bronchus gives rise to symptoms of bronchial obstruction. The first symptoms result from disturbance in the transference of air in the large bronchial tubes. Wheezing, "asthma," irritating nonproductive cough, dyspnea, transient chest pains, "choked-up sensation" and respiratory postural discomfort may thus be the initial symptoms to appear. These are often so indefinite or transient as to be entirely overlooked unless they are inquired for very carefully. When the air becomes completely shut off from the alveoli distal to the tumor, atelectasis results; but when air is entrapped, emphysema occurs.

Bronchial drainage is also interfered with by the bronchial obstruction; consequently, the next symptoms to appear are those of pulmonary suppuration. Recurring pneumonias or so-called "drowned lung" are most common, but empyema, abscess, or bronchiectasis is frequent. The suppurative sequelae may be acute and dangerous, even giving rise to metastatic brain abscess. When death occurs, it usually results from the suppuration. The bacteriology of the suppuration is varied, but may include any one or several of the oral flora.

On the other hand, the slow growth of these tumors allows time for permanent chronic changes in the lung and pleura. These chronic inflammatory changes produce permanent structural defects which remain even after local removal of the tumor. In some cases, these structural changes in the lung are intimately related to the tumor, so that the tumor could not be removed without the removal of the outer surrounding lung. (Fig. 4A and B.) In others, the tumor lies in the stem bronchus and has no immediate relation to changes in the distal lung. As time goes on, the virulence of the infection within the obstructed lung dies down and the patients exhibit little if any toxicity and appear in good health. Such patients are frequently diagnosed pulmonary tuberculosis. In these

people an astonishing degree of resistance seems to be acquired so that the smouldering infection, which may involve even an entire lung, flares up less often and produces little disability. (Fig. 5A and B.)

The cardinal symptom of bronchial adenoma is pulmonary hemorrhage, which is associated with the extreme vascularity of these tumors. They are characteristically sudden in onset and termination, bright red in color, profuse even to the extent of producing shock, unprovoked by cough or exercise, and in women frequently occur during the menstrual period. This type of hemorrhage probably arises from the tumor itself and is fed from the bronchial circulation. A second type of hemorrhage, composed of dark blood, often clotted and mixed with pus, induced by cough and exertion, and followed by blood-streaked sputum for several days, may occur. This type probably arises from the distal suppurating lung, and is fed from the pulmonary circulation. Older tumors may continue to cause hemorrhage even though the suppurative symptoms and toxemia have died down.

ROENTGENOLOGICAL FINDINGS

Roentgenologically, the appearance is bizarre (Fig. 5B) but characteristically lobar atelectasis is present and varying degrees of emphysema and atelectasis may occur. A marked shift of the mediastinum, thick pleurae, cystic whorls and abscess cavities overlie the tumor (Fig. 6A, B, C, D, E, F and G), so that it is rarely seen in the plain x-ray films. For the same reasons the extrabronchial portion and true extent of the tumor fail to be demonstrated. In an occasional case in which the tumor arises from a branch bronchus and is not surrounded by inflammatory density, a lobulated or rounded tumor mass may be visualized in an x-ray film. Such a mass may simulate a metastatic deposit rather than a primary tumor.

Tomography may delimit the true morphology, the relation to surrounding structure and the extent of the extrabronchial

portion when other roentgenologic studies fail. Tomographic findings, taken together with a bronchoscopic examination, are a

bronchial probing,[5,31] is valuable in determining the level of the bronchial obstruction and the condition of the distal
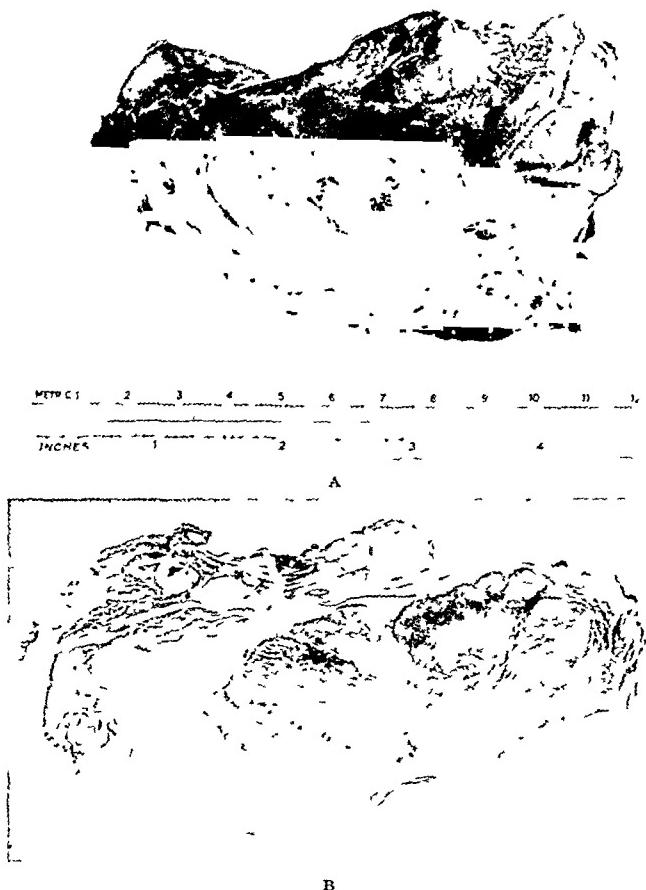
FIG. 4. Case XIX. E. A. A, lobectomy specimen of right middle lobe, showing tumor protruding through the cut right middle lobe bronchus. This patient had a duration of symptoms of approximately ten years. B, Microphotograph X 4 of section through the center of the entire specimen. Note that the tumor mass was projecting from a large cystic dilatation into the right middle lobe bronchus. This cystic dilatation was filled with hemorrhagic fluid. The surrounding lung is atelectatic, forms only a thin shell, and contains several bronchiectatic pockets. The histological picture was uniform throughout, and the pattern was similar to that seen in Figure 3E.

great aid in differentiating adenomas from carcinomas. Tomography is a new but most important diagnostic aid and this procedure should be performed routinely, particularly if adenoma is suspected. Shadows cast by areas of occult atelectasis blend with the mediastinum so that they are easily overlooked in the plain x-ray film but are strikingly depicted in the tomogram.

Bronchography, particularly with endo-

bronchi. When lipiodol is prevented from flowing into the distal lung before endoscopic removal of an adenoma, a repeated bronchogram afterwards frequently discloses marked bronchiectasis in the distal lung. Initial bronchograms are characterized by a wide column of lipiodol with a smooth concavity at the distal end, and in the lateral view a filling defect is seen along one border.

BRONCHOSCOPY

The bronchoscopist can readily determine the exact endobronchial location, the often, however, the bronchus around the tumor is distended and its cartilages are thinned out or even absent. Frequently, the

Fig. 5. Case 11. J. B. a, March 19, 1928. Posterior anterior view, taken two weeks following bronchoscopic removal of adenoma. All the tumor was thought to have been removed. b, February 15, 1940, twelve years after bronchoscopic removal. Recurrence, with complete obstruction of the right stem bronchus has taken place. The right lung is now converted into a cystic lung. General condition good. Tomograms showed extra- as well as endobronchial tumor mass.

obstructed bronchi and the relation to the carina and trachea; but he can give only a partial answer to the nature of the bronchial attachment, the amount of bronchial distention or the suppuration in the distal lung, and he can give no answer as to the extent of the extrabronchial tumor. The failure of the bronchoscopist to realize his limitations has led to the erroneous conclusions that most adenomas were wholly endobronchial.

The bronchoscopic image is that of a soft or firm mass or polyp, whitish, pink or purple. These tumors are covered with mucosa and occasionally vessels traverse the bosselated surface. Their attachment to the bronchial wall varies from a few millimeters to 2 cm. in diameter; and when this tumor can be removed endobronchially, its stalk may be seen descending between the cartilaginous rings. Most

endobronchial portions of these tumors grow in a proximal direction toward the trachea so that they fill the entire length of a stem bronchus. When they arise near the bifurcation of a stem bronchus, lobulations may extend into the branch bronchus on either side.

The bronchoscopic picture of an adenoma is usually distinctive enough to differentiate it from that of a primary bronchial carcinoma. In the latter there is ulceration and induration with the characteristic "frozen" condition of the surrounding structures, and the carina may be narrowed in the anterior posterior diameter from metastatic lymph glands in the hilar area. Adenomas, on the other hand, may be freely movable. Ulceration usually is not present and there is no infiltration of the adjacent bronchial mucosa. Occasionally, when the adenoma presents as low, broad

FIG. 6. Case XIX. E A. A and B, roentgenograms showing dense shadows at the right base occupying the right middle lobe. When compared with the surgical specimen, the actual size of the tumor is much smaller than the shadow cast. C and D, nine months later. The shadow seems slightly smaller; very little change.

induration instead of a polypoid mass, the bronchoscopic differentiation is impossible. Hemorrhage gives another important bron-

positive sputum. Bronchoscopy, of course, usually tells the story. Bronchial tuberculosis presents a flat ulcerative process,

FIG. 6. E, F and G, tomograms 8, 10 and 12 cm. from the back. Note that because of the fluid in the cyst which surrounds the adenoma even tomography fails to delimit the true size of the adenoma.

choscopic clue to the true diagnosis. We have frequently encountered rather severe bleeding from the adenomas with the least trauma, whereas the same amount of bleeding is unusual in the case of polypoid carcinoma.

Bronchoscopic removal of adenoma reestablishes the bronchial airway and also the drainage of distal infection, thus bringing about a dramatic improvement of the patient. But due to the intramural and extrabronchial extensions of these tumors, it is doubtful that every cell is removed by such treatment. Consequently, late recurrences can be expected frequently, although they may not be suspected for ten years or more. (Case II, J. B.) For this reason, patients treated bronchoscopically should always be followed by bronchoscopic examinations at intervals of no less than one year. In addition, the older tumors are so large and adherent to the thinned-out bronchial walls that endobronchial removal is impossible and may bring about an unnecessary fatality.

DIFFERENTIAL DIAGNOSIS

The finding of tubercle bacilli rules out adenoma because we have yet to see a patient with bronchial adenoma develop a

smears from which show acid-fast bacilli; while adenoma projects as a tumor mass, biopsy of which may be characteristic. Because carcinoma and other malignant tumors may present as a polypoid tumor to the bronchoscopist, adequate biopsies with careful histologic interpretations are frequently necessary to bring about early diagnosis. Gebauer[32] has called attention to the endobronchial morphology of certain adenocarcinomas which metastasize widely. We have encountered difficulty in differentiating peripheral circumscribed epidermoid, cylindrical ciliated adeno-, undifferentiated and unclassified carcinomas. Certain connective tissue tumors, such as angioendotheliosarcoma and myosarcoma, are apt to be of long duration and polypoid in nature, and for many months they may simulate adenoma. A careful and complete study of the patient, particularly with tomographic studies, may disclose the invasive nature of these tumors. Adequate biopsies containing characteristic patterns make the diagnosis certain. Bronchoscopic biopsy material from small-cell carcinoma and angio-endothelioma has proved difficult to differentiate from adenoma. Exploratory thoracotomy should not be delayed too long when the diagnosis of

adenoma cannot be substantiated in other ways. Benign bronchial tumors other than adenoma are much less common than was previously thought. Fibromas occur only about one-tenth as frequently as adenomas, and the characteristic patterns of adenomas are usually lacking in these. Ecchondromas, myomas and lipomas are also rare and have a characteristic histology. Occasionally, unclassified benign polypoid tumors occur.

Bronchiectasis is not always of the fetid type with marked cough and sputum. The hemorrhagic type of bronchiectasis may simulate the clinical picture of adenoma. When bronchiectasis has been demonstrated and hemorrhage is the chief symptom, the presence of a concomitant adenoma should be kept in mind. In such cases, bronchoscopic visualization and biopsy of the adenoma may be difficult. Tomographic studies may be of help.

TREATMENT

There are three types of treatment for bronchial adenomas: local treatment, radiation and pulmonary resection.

The local treatment may be accomplished endoscopically or by local resection through a transpleural approach. The endoscopic treatment is less commonly indicated than it was formerly thought to be, because of (1) local recurrences, (2) danger of fatal complications, (3) inability to remove adequate amounts of the tumor, and (4) disabling symptoms from the distal suppurating lung still remaining. It must be admitted, however, that where adequate bronchial drainage can be re-established by removal of the endobronchial tumor, improvement is often satisfactory; and, even though late recurrences result, the general condition of these patients may remain good for as long as twelve years. Yet even these patients eventually change from a problem of bronchoscopic therapy to one of pulmonary resection. In preparation for pulmonary resection, re-establishment of bronchial drainage by endoscopic removal of the obstructing tumor should be performed whenever it is easily accomplished.

But when these attempts are complicated by serious hemorrhage, failure to establish bronchial drainage easily or the presence of persistent obstructing tumor, then bronchoscopic treatment should be abandoned in favor of pulmonary resection.

The number of patients operated upon by transpleural approach with local resection of the tumor through an incision in the bronchus is still quite small. This method appears to be applicable to those tumors in which the distal lung has not yet been damaged permanently, in which the size is small and in which dissection is easy.

Radiation therapy probably has little effect upon the tumor *per se*. When distal infection is pronounced and bronchial obstruction complete, external radiation may produce an exacerbation of the symptoms. It is our belief that those patients who had radiation therapy continued to live, not because of the therapy, but rather in spite of it. In our hands, intrabronchial radiation therapy has proved too cumbersome and dangerous. Besides, the remaining untreated suppurating lung is apt to be the chief cause of disability and symptoms so that a cure is not obtained.

Pulmonary resection, then, is the treatment of choice in approximately 90 per cent of the patients. It accomplishes not only the complete removal of the tumor but also of the suppurating lung. Unlike carcinoma, lobectomy rather than pneumonectomy is sufficient if it includes all the tumor and the suppurating lung. Mediastinal lymph-node dissection is rarely necessary. Preoperative preparation consisting of transfusion, rest, high caloric, high vitamin diet, and release of bronchoscopic obstruction by endoscopic therapy, is important to keep the operative mortality low. Operation should not be performed during an exacerbation of the pulmonary infection or immediately after a large hemoptysis. Several weeks or months may be utilized to raise the patient's preoperative condition to the optimum.

In general, the technic of lobectomy for bronchiectasis (Brunn,[33] Churchill[34]) with hilar ligation of vessels and primary liga-

tion and suture of the bronchial stump, as described by Blades,[35] is the method of choice. Certain peculiarities of these tumors must be considered, namely, the enlargement of the bronchus due to the tumor within it, the location close to the stem bronchi, the tendency for the tumors to project towards the trachea and the adhesive pleuritis associated with a long infection. The enlargement of the bronchus disturbs the relation of the vessels so that they must be dissected out with great care at the hilum. The position of the tumors makes it necessary to amputate the lobe close to the stem bronchus. However, at times the incision in the bronchus may be made below the tip of the endobronchial tumor so that a slightly longer bronchial stump is obtained. The adhesive pleuritis frequently involves the pericardium and the adhesions may contain fairly large blood vessels. These adhesions must be ligated before they are cut.

In our series, seven of nineteen patients have had pulmonary resection performed. Three of these underwent pneumonectomies and four lobectomies. There was one operative mortality in a patient who had a pneumonectomy. In the remaining six cases the results are very satisfactory. Wherever the tumor can be removed with lobectomy alone, this should be done.

CONCLUSIONS

Bronchial adenomas are epithelial polypoid tumors which exhibit growth potentialities midway between distantly metastasizing carcinomatous and purely local polypoid bronchial tumors.

Three morphologic types occur: endobronchial, intramural and extrabronchial. The incidence of intramural and extrabronchial tumor is at least 90 per cent.

Bronchial adenomas have a characteristically long clinical course which is related to the location in the large bronchus, their vascularity and their slow growth.

Histologic examination of bronchoscopic biopsy will definitely establish the diag-

nosis only if characteristic patterns are present.

Tomography offers a diagnostic procedure that can determine the location, extent and morphology of these tumors.

Endoscopic removal of bronchial adenomas is indicated to reestablish bronchial drainage; only in the rare endobronchial type with thin pedicle can this type of removal be complete.

Pulmonary resection may be indicated because of growth of the endobronchial portion and the suppuration in the distal or surrounding lung in approximately 90 per cent of the patients.

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BRONCHIAL OBSTRUCTION*

SIGNS, SYMPTOMS AND DIAGNOSIS

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BRONCHIAL obstruction is a fundamental pathological process which plays an extensive, variable rôle in pulmonary pathology. Its influence on the lung is usually determined more specifically by the location of the lesion and the degree to which the bronchus is obstructed, than by the etiology of the process which has produced the obstruction. The effects of an obstruction of a bronchus may be widespread, and not limited to the lung distal to the obstruction. Gross, significant changes in intrathoracic pressure, circulatory changes, extensive suppurative processes and other physiologic and pathologic processes result. It is the purpose of this paper to discuss principally the mechanics of bronchial obstruction and the signs and symptoms which it produces. The disease entities which may be responsible for the obstructions, as well as those which are produced by them, will serve as illustrations.

ANATOMY

A thorough understanding of the anatomy of the tracheobronchial tree and the topographic anatomy of the lobes of the lungs and their projected physical and roentgen findings is essential to establish the exact location of the point at which a bronchus is obstructed. Most anatomy texts do not provide the description or the terminology used by the bronchoscopist or the thoracic surgeon to correlate the site of an obstructing lesion in a bronchus with the peripheral distribution of the effect of the obstruction. The recent descriptions of Neil,[1] Hasse,[2] Churchill and Belsey,[3] de Pablo,[4] Jackson and Huber,[5] Adams and Davenport,[6] and others have done much to focus attention on the importance of the segmental arrangement of the lungs and the bronchi leading to them. A review of this anatomy is somewhat outside the scope of this paper and may be obtained directly from the published works of the authors mentioned.

PHYSIOLOGY

The functions of the tracheobronchial tree are three-fold: the conduction of air to and from the lungs, the final preparation of the air for the lungs, and the drainage of secretions and foreign material from the lungs. The manner in which the first of these functions is executed determines in a large measure the mechanics of bronchial obstruction. The tracheobronchial tree cannot be considered merely as a fairly rigid tubular system, but rather as a dynamic conductor system whose rôle is anything but passive. The bronchi dilate and constrict, and lengthen and shorten during inspiration and expiration. Further, they deviate inferiorly and superiorly as the lungs follow the excursion of the diaphragm with a total resultant motion simulating peristaltic waves.

The second function of the tracheobronchial tree, that of the final preparation of air for the lungs, is of relatively little direct significance to bronchial obstruction. It consists simply of warming and humidifying the air, and of removing foreign material held in suspension in the air.

The third function, that of drainage, is influenced more than mechanically by a

bronchial obstruction. Normally, this function is carried out by a number of contributing factors, including the action of the cilia, the action of the glands of the bronchial mucosa liquefying secretions, the respiratory movements, the tussive squeeze of the cough reflex and finally the blast of the cough itself as the built-up intrabronchial and intratracheal pressure is released by a sudden opening of the glottis. Almost any degree of obstruction anywhere in the tracheobronchial tree will influence one or more of these actions, producing profound changes in bronchopulmonary physiology. These changes may be in the nature of a loss of control of intrathoracic air pressures, a further loss of the important relationship of these pressures to blood flow within the chest, and massive retentions of the products of glandular secretions with superimposed infections.

The discussion of the physiologic effects of respiratory obstruction should be amplified because their critical analysis may not infrequently result in the prevention of irreparable damage. Dyspnea is the first of these effects. It may be defined simply as an abnormal increase in breathing effort and its onset may cause one of three phenomena to take place: either an increased rate of ventilation or minute volume of air breathed, maintenance of the previous normal level of ventilation through a neutralization of the effects of the added ventilation by the increased effort expended, or a decrease in the ventilation to a level below normal. However, it must be remembered that the normal individual sitting quietly in a chair can double the rate of pulmonary ventilation with no obvious effort and that the changes would be recognized only by the trained observer. Therefore, in the dyspneic patient it is essential to evaluate the air movement in and out of the chest to determine whether a bronchial or tracheal obstruction is compensated by the dyspnea, or is decompensated and requires urgent relief in the form of oxygen or surgical interven-

tion before the decompensation becomes irreversible.

The cause of dyspnea may be reflex or physiochemical, or a combination of these two factors. Reflex dyspnea is the result of abnormal kinetic afferent impulses arising in the muscles of respiration and in the musculature of the tracheobronchial tree through the Hering-Breuer reflex. These impulses are initiated by an impedence of the air flow or by a reduction in its velocity, and are responsible, together with certain physiological phenomena, for the subjective sensations which cause dyspnea. The physiochemical factor responsible for dyspnea in tracheobronchial obstruction is produced both by an increase in the carbon dioxide content of the blood, which stimulates the respiratory center, and by a decrease in the oxygen content of the blood, which increases the irritability of the respiratory center.

Great variability exists between individuals in their response to abnormal respiratory conditions. An occasional patient is seen whose dyspnea may be entirely of the reflex type and may become so severe that intervention is necessary even though respiratory decompensation has not occurred. In a similar way there may be a variation in response to the rise of carbon dioxide in the blood. Anoxia may develop gradually and be tolerated without great difficulty. However, with the sudden relief of a chronic tolerated anoxia, as may occur following a tracheotomy or the removal of an obstructing foreign body, the carbon dioxide may be exhaled so rapidly and the anoxia relieved so quickly that the lack of stimulation of the center and its decreased irritability may result in a respiratory paralysis and death. A similar action, less severe in degree, may follow the administration of oxygen in other types of respiratory decompensation. In chronic hypertrophic pulmonary emphysema, for instance, oxygen may cause severe psychotic symptoms which gradually improve as the therapy is continued.

In the diagnosis as well as in the management of obstructive diseases it is imperative to recognize the onset of respiratory decompensation as it manifests itself by the presence or the onset of anoxia. When anoxia starts, the metabolic processes in the body are impaired and muscular strength and ability are decreased. Intervention becomes imperative because the course is unfavorable and the point may soon be reached when relief may not be effective. The recognition of anoxia in the early stages is difficult and the only reliable although impractical method is by oxygen concentration determinations of arterial blood. Probably the most significant finding is the change in the minute volume of ventilation. When this is reduced and especially when it is combined with a change to rapid and shallower breathing, anoxia has started and extreme measures in the relief of the obstruction are indicated. Cyanosis is not always a reliable sign, either by its absence or its presence. A sudden increase or even decrease in the pulse or respiratory rate and a rise in body temperature out of proportion to a superimposed infection are significant signs. The most important single observation in the general appearance of the patient is the presence or absence of exhaustion.

Alterations in the intrabronchial and intrathoracic pressures are responsible for the second group of changes in physiology which follow respiratory obstructions. These alterations directly affect the blood flow through the chest, and the secretion of fluids into the alveoli and bronchi. Kernan and Barach,[7,8] Galloway,[9] Gailbraith,[10] Adams and Livingston,[11] and others have emphasized these effects and have reviewed the related literature. The entire subject of experimental bronchial obstruction is so extensive that in this discussion the findings can only be summarized. It has been shown that the increased positive pressure of expiration has no appreciable effect on the blood flow. However, the increased negative pressure on inspiration has definite harmful effects which may be summa-

rized as follows: (1) Negative intrathoracic pressure results in an increase in the pulmonary capillary blood pressure
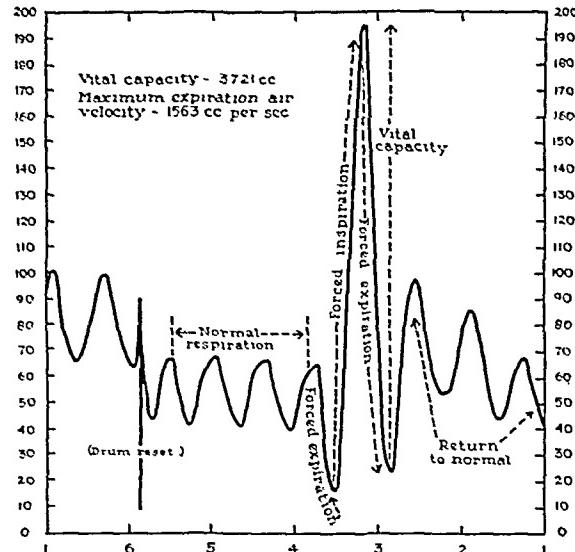
Fig. 1. Normal respiratory curves recorded on a high speed recording drum.

with transudation of serum into the alveolar spaces. This is a direct result of the increased negative pressure on the heart and circulation. The high negative intrathoracic pressure increases the return flow of blood to the heart so that the blood flow through the chest is increased. The flow of blood from the intrathoracic to the extrathoracic aorta and large arteries is likewise hindered by the negative pressure, thus putting an additional load on the left ventricle. As the negative pressure rises these two effects just mentioned increase until a progressing accumulation of blood occurs in the lungs causing the rise in capillary blood pressure with congestion, transudation, and pulmonary edema. (2) Exudation of fluid into the alveolar spaces and bronchioles because of the suction action of the intrabronchial and intraalveolar negative pressure. (3) A vicious cycle producing a further increase in the negative pressure due to the attempt to compensate for the effects of the other two actions by increasing the respiratory effort.

Thus, the physiologic effects of tracheobronchial obstruction may be divided into their respiratory and their cardiovascular actions. Mild obstruction results in a dyspnea which remains compensated by

reflex and physiochemical stimulation. Severe obstruction results in respiratory decompensation, or anoxia. The cardio-

moves in and out of the chest with each respiration, serves as a ventilating mechanism. The air stream does not actually
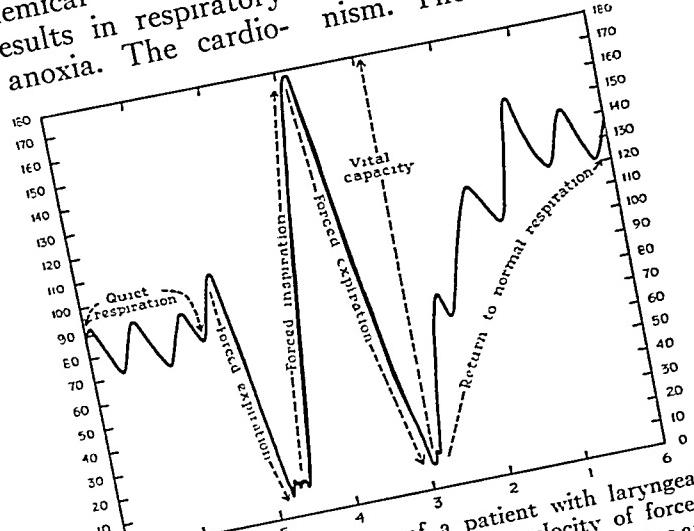
FIG. 2. Respiratory curves of a patient with laryngeal obstruction. The uniformity of the velocity of forced expiration and forced inspiration and their slow rates are the characteristics of this type of obstruction.

vascular phenomena manifest themselves by a pulmonary edema and finally a circulatory failure due to rising intra-thoracic negative pressures.

The actual measurement and mathematical interpretation of the degree or

enter the alveoli except in extremely high ventilation. The second and most important mechanism of respiratory exchange is through diffusion. These two mechanisms allow the alveolar air to be fairly constant in its oxygen and carbon dioxide concentrations throughout inspiration and expiration so that the exchange of the gases between
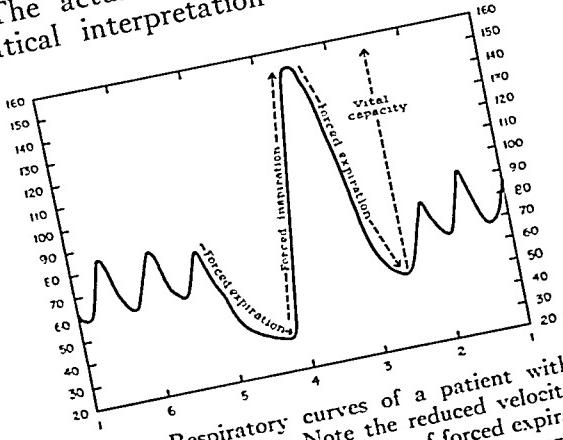
FIG. 3. Respiratory curves of a patient with bronchial asthma. Note the reduced velocity on expiration, the long curve of forced expiration contrasting sharply to the straight curve of rapid, regular inspiration.
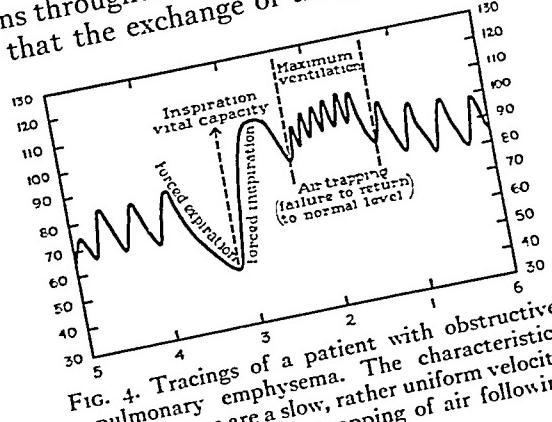
FIG. 4. Tracings of a patient with obstructive pulmonary emphysema. The characteristics of this curve are a slow, rather uniform velocity of expiration, and a trapping of air following forced inspiration.

character of a bronchial obstruction is based upon the physiology of the respiratory exchange. The supply of oxygen to the alveoli and the removal of carbon dioxide is accomplished by two different mechanisms: the tidal air, i.e., the air which

the blood and alveolar air goes on continuously and quite uniformly.

The functional examination of respiration is a clinical method of spirometry which records graphically the movement of air in and out of the chest. The Benedict-

Roth metabolism apparatus modified by the addition of a high speed drum is the apparatus of choice and the technic has been described by Barach[12] and Cournand[13] and their co-workers and by Andrews.[14] This method records the ventilation and tidal air, and also reveals the qualitative characteristics of respiration which are of diagnostic significance in respiratory obstructive diseases. (Fig. 1.)

Respiratory obstruction in the larynx and trachea shows a symmetrical slowing of inspiration and expiration at the extremes of the vital capacity tests. (See Fig. 2.) Bronchial asthma (Fig. 3) is characterized by a curved expiratory tracing and obstructive emphysema (Fig. 4) by a moderately slowed expiratory velocity and trapping of air on successive maximum expiratory efforts. Such examinations can be used not only in the differential diagnosis of these various types of obstructive diseases, but also to demonstrate the effectiveness of therapeutic procedures such as oxygen, helium, positive pressures, and the changes after the administration of drugs.

ETIOLOGY

A division of the lesions responsible for bronchial obstructions into intrabronchial, endobronchial and extrabronchial groups serves as an etiologic classification. Indirectly, the age of the patient must likewise be considered a factor influencing the pathological condition produced by a bronchial obstruction. The small caliber of the trachea and bronchi of infants is responsible for extensive pulmonary changes produced by lesions which would be insignificant in the air passages of a child or an adult. Similarly, the very soft nature of the cartilage of the trachea and bronchi of infants permits easy compression of the airway which would be impossible in the more rigid bronchi of adults. The fundamental mechanics of the changes produced by bronchial obstruction in infants, however, are identical to those found in adults.

Intrabronchial obstructions present the

most striking and illustrative examples of the various effects of bronchial obstruction. Into this division fall the cases of intra-
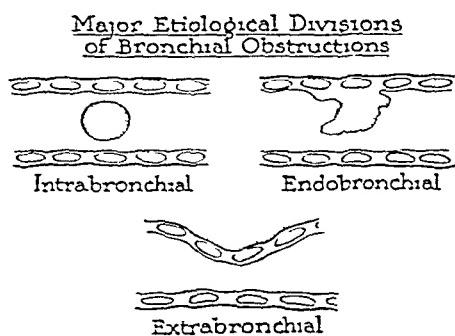
FIG. 5. Diagrammatic representation of bronchial obstruction produced by intrabronchial, endobronchial and extrabronchial lesions.

bronchial foreign bodies,[15] postoperative massive collapse of the lungs,[16] the bronchial obstructions produced by exudates in laryngotracheobronchitis,[17] and atelectasis produced by the thick plugs of asthma.[18] Intrabronchial obstructions may be further subdivided into endogenous and exogenous types. Broncholiths, thick, tenacious, bronchial secretions, inflammatory exudates, and occasionally the material from a lymphnode which has eroded through the bronchial wall, comprise the endogenous obstructions. Foreign bodies of every description make up the large list of exogenous elements which produce intrabronchial obstruction. The recognition and description of many phases of the whole problem of bronchial obstruction, with studies of its physiology and morbid anatomy were, in a large measure, possible through clinical and experimental studies of the effects of these foreign bodies in the air and food passages.

Endobronchial obstructions are due to lesions of the bronchial mucosa, musculature or cartilagenous wall. They have assumed a constantly increasing importance as bronchoscopy and bronchography have demonstrated not only their presence but also their effect on bronchopulmonary physiology. They consist of inflammatory swellings or cicatricial stenoses of the mucosa which partially or completely occlude the bronchial lumen; the various

types of infiltrative, ulcerative, granulomatous or cicatricial tuberculous lesions;[19,20] the specific inflammatory lesions of syphilis, rhinoscleroma and leprosy with the characteristic deforming scars which these lesions produce when healing;[21] and both benign and malignant neoplasms. The distortions produced by the kinking or twisting of the bronchial walls following such procedures as prolonged artificial pneumothorax, thoracoplasty or injuries must likewise be included in this group, although they should not be confused with compressions of the walls for which many of these same factors may be responsible.

The extrabronchial factors of bronchial obstruction consist of lesions in the mediastinum, heart or lungs which compress the lumen of a bronchus by pressure from outside the bronchial walls. Of these, enlarged tracheal and hilar lymph-nodes, both tuberculous and nontuberculous, are the commonest of the non-neoplastic lesions. These nodes at times assume an extreme size and compress the trachea or both bronchi to the point of asphyxia. Enlarged mediastinal nodes are fairly common in children[22] in whom, because of the soft nature of the cartilagenous bronchial wall and the relatively small size of the lumens of the major bronchi, severe dyspnea may be produced by a relatively mild degree of enlargement of the nodes. Other extrabronchial lesions producing bronchial compression consist of pulmonary and mediastinal tumors, aneurysms, cardiovascular anomalies, esophageal tumors or even occasionally esophageal foreign bodies.

The following is an outline of the etiology of bronchial obstruction: (See Fig. 5.)

I. Intrabronchial Obstructions
   A. Endogenous
      1. Secretions
      2. Exudates
      3. Broncholiths
      4. Contents of ruptured lymph-nodes
   B. Exogenous
      1. Foreign bodies
      2. Aspirated stomach contents

II. Endobronchial Obstructions
   A. Congenital web
   B. Nonspecific inflammatory processes
      1. Edema
      2. Infiltration
      3. Cicatricial stenosis
   C. Specific inflammatory processes
      1. Tuberculosis
         a. Edema
         b. Infiltration
         c. Granulomas
         d. Ulceration
         e. Stenosis
      2. Syphilis
      3. Rhinoscleroma
      4. Leprosy
   D. Distortion of the walls
      1. Kinking
      2. Twisting
   E. Neoplasms
      1. Benign
      2. Malignant

III. Extrabronchial Obstructions
   A. Inflammatory
      1. Enlarged lymph-nodes
      2. Mediastinal abscess or phlegmon
      3. Lesions of the vertebra
   B. Cysts
      1. Pulmonary
      2. Mediastinal
   C. Emphysema
   D. Neoplasms
      1. Mediastinal
      2. Pulmonary
      3. Esophageal
   E. Cardiovascular
      1. Aneurysm
      2. Heart
         a. Dilatation of left auricle
         b. Enlargement (congenital heart disease)
         c. Anomalies
   F. Esophageal foreign bodies

As with any type of classification, it is difficult to separate or segregate any of these factors in an absolute manner. A number of overlapping manifestations occur with many of the lesions, and it may be

impossible to determine the one most responsible for an obstruction in any given case. For instance, an endobronchial tumor

be illustrated by a model such as that which Eloesser and Freeman[24] have constructed. The simplest, or by-pass valve, consists of a

Inspiration ----->

BY-PASS VALVE

---Inspiration--->
(Valve open)

CHECK VALVE

Disturbed air producing wheeze
Expiration

Expiration
Valve closed

Inspiration
(Valve closed)

STOP VALVE

Inspiration

BALL VALVE

Expiration
(Valve closed)

Expiration
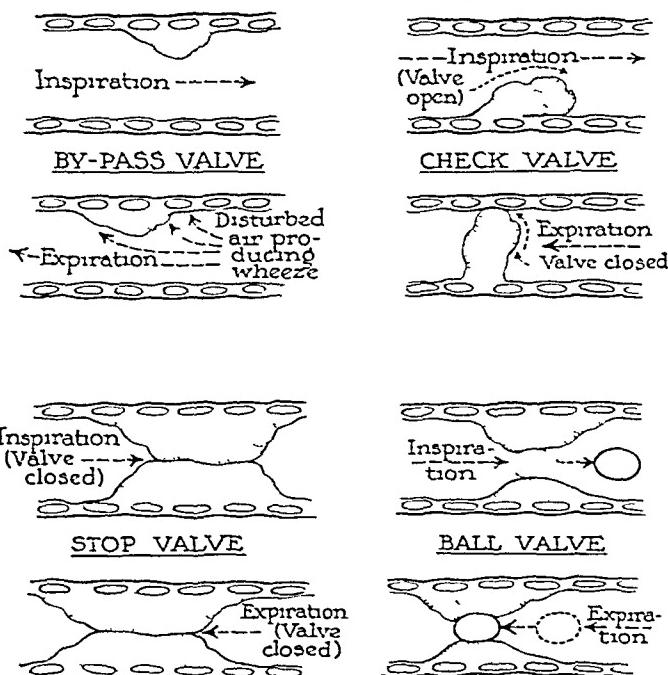
FIG. 6. Diagrammatic representation of the manner in which the four types of valves act to produce bronchial obstruction.

may partially obstruct a bronchus, but total obstruction of the bronchus may follow because of compression by the extra-bronchial portion of the tumor.

TYPES OF BRONCHIAL OBSTRUCTION

Important as are the factors which produce bronchial obstruction, it is the degree of the obstruction and its location which are responsible for the pathological condition of the lung beyond the point of obstruction. In the majority of instances, the mechanics of obstruction can best be described by designating the obstructions as valves in a system of tubes. (See Fig. 6.) As the Jacksons[23] point out, however, these tubes are only semi-rigid and they are not of constant caliber. Inspiration is accompanied by an expansion of the bronchus and expiration by a contraction. Consequently, numerous factors enter into the mechanics of each particular obstruction, but three types of phenomena form the basic physical effects of bronchial obstruction. These are well known but will be briefly reviewed. Their mechanics can best

small decrease in the size of the bronchial lumen such as might be caused by an object lying across the diameter of the bronchus, the lumen remaining large enough to allow air to pass easily to and fro, without appreciably changing the volume of air entering or leaving the lung beyond the point of obstruction. Air passing back and forth over this irregularity is not actually obstructed except in that the column of air is broken to form eddies. Such an obstruction may be produced by a small mucous plaque on the bronchial wall, a small irregularity of the bronchial wall due to an early bronchogenic carcinoma, or a foreign body, such as an open safety pin lying loosely in the bronchus. The only evidence that can be obtained of the presence of such an obstruction is a limitation of motion of the chest on the affected side[25] and a wheeze heard at the open mouth or on auscultation over the chest, loudest at the point of obstruction.

The second type of bronchial obstruction is observed when the obstruction has become more marked. It is characteristically

produced by many foreign bodies such as nut kernels, and is present at some stage of the growth of most endobronchial

classical signs are a shift of the heart and mediastinum toward the uninvolved side on expiration with a return to the normal
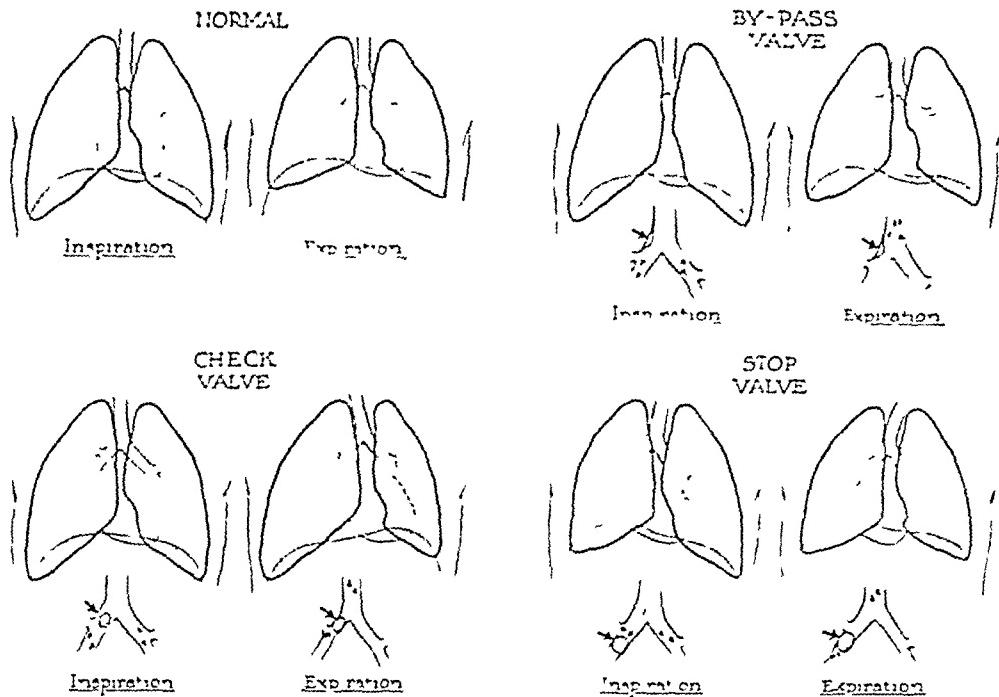
FIG. 7. Positions of the lungs, heart, trachea and diaphragm during inspiration and expiration in the various types of bronchial obstruction.

tumors or cicatricial bronchial stenoses. It is designated as a check-valve or ball-valve type of obstruction because air may pass in one direction only, and is dependent upon the physiological bronchial expansion and contraction which occur during normal respiration. Thus, if a foreign body lies in the bronchial lumen, air may pass it freely during inspiration as the bronchus increases in size. During expiration, however, the bronchial wall collapses around the foreign body, obstructing the flow of air out of the lung distal to the foreign body. Another factor contributing to this type of expiratory obstruction is the fact that the force of inspiration is greater than that of expiration. This difference increases with respiratory embarrassment. On subsequent respirations, as more and more air becomes trapped, an emphysema develops in the lung distal to the obstruction. This may be observed by physical signs, on the fluoroscopic screen or on roentgen films taken at inspiration and expiration. The

position on inspiration and a stationary, depressed diaphragm, emphysema, and widened and immobile intercostal spaces on the involved side.

It is possible, of course, that this type of obstruction may involve only the bronchus leading to a single lobe, and thus may produce a marked emphysema of one lobe alone or a cavity simulating a lung abscess.[26,27] Similarly, if the bronchiole leading to a lobule is thus involved, a bullous emphysema may occur, which may rupture and produce a pneumothorax.[25] An emphysema extending under the visceral pleura and into the mediastinum may also follow such an obstruction.

A difference between the mechanics of the check-valve and the ball-valve does exist. However, their ultimate action in regard to bronchial obstruction is, in most instances, identical. In the check-valve, the valve seat remains in a constant position, opening and closing as the bronchus expands and contracts. In the ball-valve,

the obstructing element moves back and forth during inspiration and expiration, moving into and out of the valve seat. Under certain conditions, the check-valve or the similar ball-valve acts in the reverse manner, allowing air to leave but not enter a bronchus. Under such conditions, the lung rapidly becomes airless or atelectatic and the signs and symptoms are those of atelectasis.

Complete obstruction of a bronchus, allowing no air to pass the obstruction either on inspiration or expiration, is designated as a stop-valve obstruction. Following such an obstruction the air in the portion of the lung beyond is absorbed and the lung becomes airless and shrunken, or atelectatic. A typical example of such an obstruction is the complete occlusion of a bronchus by a round foreign body such as a nail head, or by an extensive, fungating bronchogenic carcinoma. The typical findings which characterize such an atelectasis are the density of the area beyond the obstruction, the shift of the heart and mediastinum toward the involved side, the elevation of the involved diaphragm and narrowing of the intercostal spaces on the involved side. The opposite lung, if the atelectasis is extensive, shows some degree of compensatory emphysema.

Figure 7 illustrates the position of the heart, diaphragm, trachea and lungs during inspiration and expiration in each of these types of bronchial obstruction.

SIGNS AND SYMPTOMS

From the foregoing discussion, it is apparent that three principal factors determine the signs, symptoms and ultimate pathological condition of an obstruction of the lower air passages. The first of these is the level in the tracheobronchial tree at which the obstruction occurs; whether it is in the trachea, a major bronchus, or a bronchiole. Grossly, this may be considered as an anatomical factor. The second principal factor is the degree to which the air passage is obstructed; i.e., whether the action produced is that of a by-pass valve,

check-valve, or stop-valve. This factor is a functional one. Finally, the signs and symptoms will be dependent, but to a lesser degree, upon the relation of the obstruction to the bronchial walls; whether it is an intrabronchial, endobronchial, or extrabronchial obstruction. This is an etiologic factor. As these factors act collectively to produce bronchial obstruction they must be considered as they collectively produce the various signs and symptoms of bronchial obstruction.

The symptomatology of bronchial obstruction is for the most part not characteristic of bronchial obstruction per se; certain underlying symptoms are fairly constant, however, influenced in each case by the underlying etiologic factor. Other symptoms become important only when they are associated with a history of a bronchopulmonary pathological condition. A cough, suggestive of bronchial irritation, may not in itself be significant, but it is one of the most constant symptoms of bronchial obstruction. It may be dry and entirely unproductive for weeks and suddenly be associated with hemoptysis and a foul, purulent sputum produced by a superimposed infection.

A wheeze is also an extremely important symptom because, as stated above, an object lodged in a bronchus permitting air both to enter and leave the bronchus freely will produce none of the changes in the lung distal to the obstruction which are so characteristic of the other types of bronchial obstruction. Thus, with no abnormal physical findings, the wheeze heard throughout the chest, loudest over the location of the obstruction, may be the only sign or symptom of the object if it is nonopaque to x-rays.

Dyspnea is likewise an outstanding symptom of tracheal or bronchial obstruction. All degrees of dyspnea may be noted from the rapidly fatal dyspnea accompanying an obstruction at the bifurcation of the trachea to the sensation of constriction of the chest, or chest discomfort which is a characteristic expression used by patients

with early bronchial neoplasms. Pain is not a common symptom unless the underlying pathological condition is extensive and associated with destructive changes. Patients with sharp foreign bodies in the bronchi rarely complain of pain, although irregular objects such as sharp bone fragments or dental fillings occasionally cause pain which the patient may localize quite accurately to the site of the foreign body.

Certain symptoms should be mentioned as characteristically accompanying lesions that produce bronchial obstructions. The *enlargement of the neck and venus engorgement of the neck and chest* which follow upper mediastinal neoplasms are examples of such symptoms. Similarly, the hoarseness due to a paralysis of the left vocal cord following involvement of the left recurrent laryngeal nerve in a neoplastic process at the hilus is a symptom of that type of neoplasm.

Hemoptysis is one of the most important symptoms of any type of pulmonary pathological condition. In reference to bronchial obstruction it is not infrequently the first evidence of the presence of an intrabronchial foreign body or an early bronchogenic carcinoma. Benign bronchial neoplasms have been known to manifest themselves by this symptom many months before their slow growth occludes the lumen of the bronchus to give further evidence of their presence.

PHYSICAL FINDINGS

In spite of the extremely important rôle which roentgenology plays in the diagnosis of diseases of the chest, the physical examinations in themselves not infrequently lead to important clues which finally establish the correct diagnosis, in spite of contrasting or negative roentgen findings. One of the most constant signs in almost all cases of bronchial obstruction is a definite limitation of motion on the involved side, independent of the degree of the obstruction. Careful inspection of the chest is thus of great diagnostic importance in spite of its apparent simplicity.

Other signs and symptoms are more dependent upon the degree of the obstruction and on its location.

TRACHEAL OBSTRUCTION

Tracheal obstruction may manifest itself by all the signs and symptoms of acute respiratory obstruction, leading to a rapid fatality; in the other extreme, it may manifest itself only through the simplest sign of obstruction to the airway, a wheeze. Foreign bodies loose in the trachea may be heard flying back and forth from the larynx to the carina during respiration, a finding which Jackson[23] has designated as an "audible slap" which is accompanied by a "palpatory thud" if one palpates the larynx. The "asthmatoid wheeze" is invariably present in such obstructions associated with a cough, dyspnea and, if the obstruction persists, cyanosis. A stridor, distinct from a wheeze, is often characteristic of tracheal obstructions, with the associated indrawing of the suprasternal notch, the epigastrium and the intercostal spaces. Tracheal obstructions due to mediastinal neoplasms not infrequently involve the esophagus as well, and consequently the patient complains of difficulty in swallowing and the regurgitation of food into the trachea due to esophageal overflow.

Auscultatory findings in tracheal obstructions are a loud stridor, wheeze and sonorous rales heard throughout the chest. These are generally accompanied by a diminution of the intensity and excursion of the breath sounds and a change in the percussion note, depending upon the degree of obstruction, i.e., if an obstructive emphysema has been produced, a hyperresonant or tympanitic note will be heard; whereas if the obstruction has produced a drowned lung, the chest will be dull to flat on percussion.

Obstructions at the bifurcation of the trachea are most interesting and many times extremely confusing because they may produce opposite types of obstruction in the two major bronchi. A tumor at the

bifurcation of the trachea may only partially obstruct both major bronchi, giving the findings of a bilateral obstructive emphysema. Or, it may completely occlude one bronchus and partially the other, resulting in an atelectasis of one lung with an obstructive emphysema of the other. Such patients at times present rapidly changing findings as one or the other major bronchus opens due to the extreme respiratory effort the patient makes to breathe. Two foreign bodies aspirated at the same time present findings identical to those of a tracheal obstruction. Thus, a child who chokes while eating peanuts may aspirate one part of a kernel into the right main bronchus, and then, following the next cough, inspire a second piece which is sucked into the left bronchus because of the occlusion of the right. The bilateral obstruction which results is indistinguishable from a tracheal obstruction.

OBSTRUCTION OF A MAJOR BRONCHUS

Partial obstruction of a major bronchus results in complete unilateral, obstructive emphysema. This is characterized by findings of limited expansion, relative hyperresonance to tympany and a marked suppression of breath sounds on the involved side. It may be accompanied by an inspiratory and expiratory wheeze and occasionally by rales or rhonchi. The heart and mediastinum are shifted to the uninvolved side on expiration, and, as Eloesser[21] states, the affected side of the chest is dilated rather than shrunken. With complete obstruction to the bronchus one may have the signs and symptoms of pneumonia or an empyema due to the "drowned lung." The distinguishing feature is the marked decrease in size of the lung distal to the point of obstruction compensated by a shift of the heart toward the involved side and an elevation of the diaphragm on the involved side. There are generally many rales present, but these depend to some extent upon the degree of secondary infection. There is a limitation of motion, dulness to flatness on percussion, and fre-

quently marked bronchial breathing and bronchophony in the early stages of the atelectasis with breath sounds entirely absent if the atelectasis is of long duration or is extensive.

Obstruction of the bronchi leading to single lobes produces varying degrees of signs and symptoms dependent, generally, on the underlying pathological condition and degree of infection rather than upon the fact that the bronchus is obstructed. Both lower lobes are not infrequently involved in inflammatory obstruction,[29] giving relatively mild symptoms. However, the essential findings are similar to those described as following an obstruction of a major bronchus, except that they are more limited in their extent to the topographic outline of the lobe.

ROENTGEN FINDINGS

The roentgen aspects of the diagnosis of bronchial obstruction depend upon a complete roentgenographic study of the chest. The practice of basing an interpretation on one or two views of the chest leads to gross errors not only regarding the presence or absence of an obstruction, but also the location of the lesion. Fluoroscopically, areas of density or emphysema, the motion of the diaphragms and the shifting position of the heart and mediastinum on inspiration and expiration are significant. While there are no actual roentgen findings in the bi-pass type of valve obstruction, unless the obstructing element itself is an opaque object, such as a common pin or a nail lying across the bronchial lumen, (see Fig. 8) the fluoroscopic findings of the next degree of bronchial obstruction, namely, that due to a check or ball-valve, are of greatest importance in establishing the diagnosis. They had been observed in individual cases for a number of years, but the extensive work of Manges[30] led to their widespread recognition and acceptance. He stated that the fluoroscopic findings of such an obstruction were an increase in the transparency of the affected lung, a depression and limitation of

motion of the diaphragm on the involved side, a displacement of the heart and mediastinal structures toward the unin-

trapped air and its resulting physiologic phenomena as Manges described them.

The roentgen findings in complete bron-

Fig. 8. Roentgenograms illustrating the first degree of bronchial obstruction. The patient was a bill-poster who aspirated two tacks when he fell off a ladder. A constant wheeze heard equally on both sides of the chest led to the diagnosis of "asthma." The foreign bodies, one in each main bronchus, were finally removed bronchoscopically eight years after the accident. Note the absence of pathologic changes in the lungs distal to the foreign bodies, characteristic of this type of bronchial obstruction.

volved side on expiration, and finally a compensatory increase in the motion of the diaphragm on the uninvolved side. (Fig. 9.) Bronchoscopic observations have confirmed the roentgen interpretation that these findings were due to the presence of bronchial obstructions innumerable times. Further studies of these phenomena have been made to demonstrate areas of partial bronchial obstruction in which pulmonary tissue composing less than a lobe was involved. Golden[31] reported the fluoroscopic observation of abnormal respiratory displacement of the lower lung structures parallel with the movement of the diaphragm as the first evidence of obstructive emphysema in two cases.

As is well known, obstructive emphysema may be recorded on the roentgenogram by making exposures at extremes of the respiratory cycles and comparing the positions of the diaphragms and mediastinum as well as the density of the lungs on the two exposures. Thus, while a film made on deep inspiration shows both lungs completely inflated in this type of obstruction, the expiration film demonstrates the

chial obstruction are more obvious than those in partial obstruction because of the area of density distal to the obstruction. (Fig. 10.) In complete obstructions of the main bronchi, the well known findings are the shift of the heart and mediastinal structures toward the involved side during both phases of respiration, the elevation and fixation of the diaphragm on the involved side, and the density of the atelectatic lung. These findings are associated with a compensatory emphysema of the opposite side. Complete obstructions of the bronchi leading to single lobes or parts of lobes have less influence on the heart and mediastinal structures although they usually do give roentgen evidence of a shift of these structures toward the involved side, thus aiding in the differentiation between an atelectasis, a consolidation or a drowned lung. Atelectatic lobes or parts of lobes generally assume a more or less triangular shape and are frequently designated as triangular shadows.[32] It may be generally assumed that the bronchial obstruction in such triangular shadows lies at the apex of the triangle. However, it is essential

that the shadow be studied roentgeno-graphically in two planes, in order that the particular obstructed bronchus may be accurately localized.

BRONCHOGRAPHY

The importance of roentgen visualization of the bronchi was realized by Jackson[33] who in 1918 made the first satisfactory bronchograms by means of bismuth insufflations into the bronchi through a bronchoscope. Sicard and Forestier[34] using iodized poppy-seed oil (lipiodol) added a greatly improved radio-opaque medium which readily lent itself to intrabronchial instillation. At the present time, a variety of halogenated oils[35] is used, making the practice of roentgen visualization of the tracheobronchial tree a routine procedure in examinations of the bronchopulmonary system. A standard technic may be described as follows:[36] "In the adult the pharynx and larynx are anesthetized by means of 2 per cent pontocain spray followed by the instillation of 2 cc. of the same solution into and through the larynx, by means of a laryngeal syringe under mirror guidance. Again under mirror guidance a catheter on a curved wire stylette is passed through the larynx. The stylette is then removed as the catheter is advanced down the trachea. Under the fluoroscope the warmed oil is instilled into the desired area by manipulating the distal end of the catheter. In this manner the injection is limited to the area to be studied, and the subsequent films, taken immediately, present no confusion of superimposed shadows. Antero-posterior, lateral, and oblique films are indicated. In children, the catheter may be passed through the nostril and guided into the trachea under direct laryngoscopy. No anesthesia is necessary. Numerous bronchoscopists prefer the bronchoscope for the purpose of introducing the oil; some clinicians favor the perglottic method and others the laryngeal cannula, intubation cannula, or rubber catheter placed into the larynx as described above; some

find that excellent results are obtainable by introducing the material supraglottically, while others prefer to inject the material through the cricothyroid membrane."

A detailed discussion of this subject with an extensive review of the literature and the technic may be obtained from the comprehensive article by Jackson and Bonnier[37] in which they stress the advantages of the catheter methods of instillation of the oil. From the roentgenographic standpoint they stress the importance of unilateral filling in certain cases in which the lateral view will play a determining factor in interpretation of the pathological condition, and the value of the oblique views if both major bronchi have been filled with oil.

Careful guidance of the oil into the areas requiring particular study is essential to obtain a complete visualization of the existing condition. This may be done only through fluoroscopic guidance of the oil as it enters the bronchi, and the tilting of the patient into such a position that the oil runs into the desired areas, whether they be lower, middle or upper lobes.

According to Farinas,[38] the use of iodized oil in bronchography has many disadvantages. These include its high viscosity which prevents its flow into certain stenotic areas, thus failing to show the extent of a stenosing lesion, as well as the fact that it remains in the lung parenchyma for long periods of time, especially in cases of incomplete bronchial stenosis. Farinas has substituted solutions of organic salts of iodine, such as uroselectan, for the iodized oil in such examinations. He finds these salts entirely nontoxic and nonirritating. Furthermore, their viscosity permits easy flow through any stenosis, and finally, they are rapidly and completely absorbed by the broncho-alveolar mucosa. Because of this rapid absorption it is necessary to take films while the solution is being injected.

Recent improvements in the technic of planography have added another diagnostic procedure which is available to aid
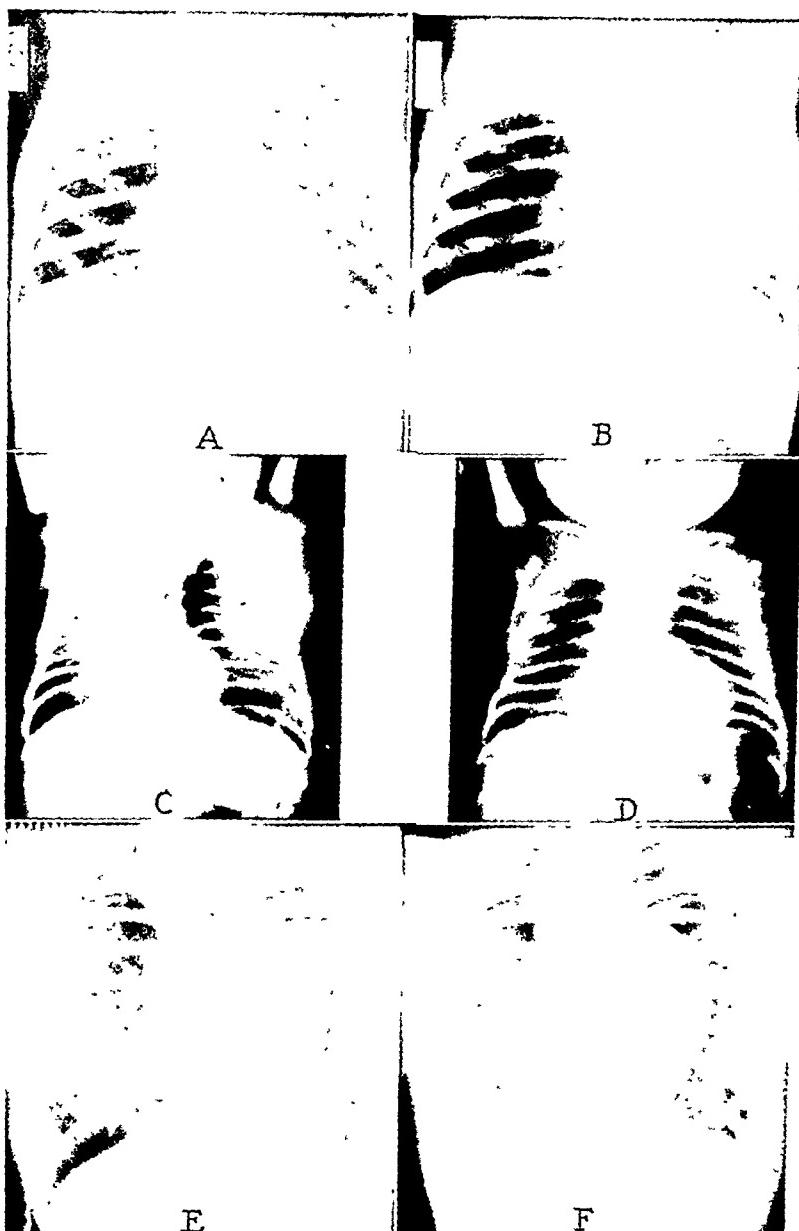
FIG. 9. Three cases of obstructive emphysema. A, inspiration, B, expiration films of a six-year-old girl who had an *intrabroncbial* obstruction (peanut) in the right bronchus which functioned as a check valve. While a slight emphysema is apparent on the right side on inspiration, the diaphragms and position of the heart are normal. On expiration (B), however, the emphysema *on the right side becomes very pronounced; the heart and mediastinum shift to the left and the right diaphragm remains stationary.* The difference in the intercostal spaces on the two sides is striking and serves as an additional diagnostic feature. C, extreme obstructive emphysema of the left lung produced by an *endobronchial* lesion, a congenital web in the left main bronchus. The infant, twenty-four hours old, was in extreme respiratory distress, with tympany and absent breath sounds on the left side of the chest. A bronchoscopic examination revealed the web and it was dilated with forceps. D, roentgenogram forty-eight hours later. Breath sounds were equal on the two sides of the chest and fluoroscopy as well as the roentgenogram showed the heart and mediastinum to have returned to their normal positions. E, obstructive emphysema of the left lung due to an *extrabronchial* lesion, an aortic aneurism, which compressed the left main bronchus. Roentgenogram taken on deep inspiration. F, roentgenogram taken in deep expiration. The left diaphragm has remained stationary, the mediastinal structures have shifted toward the right and air has been trapped in the left lung.
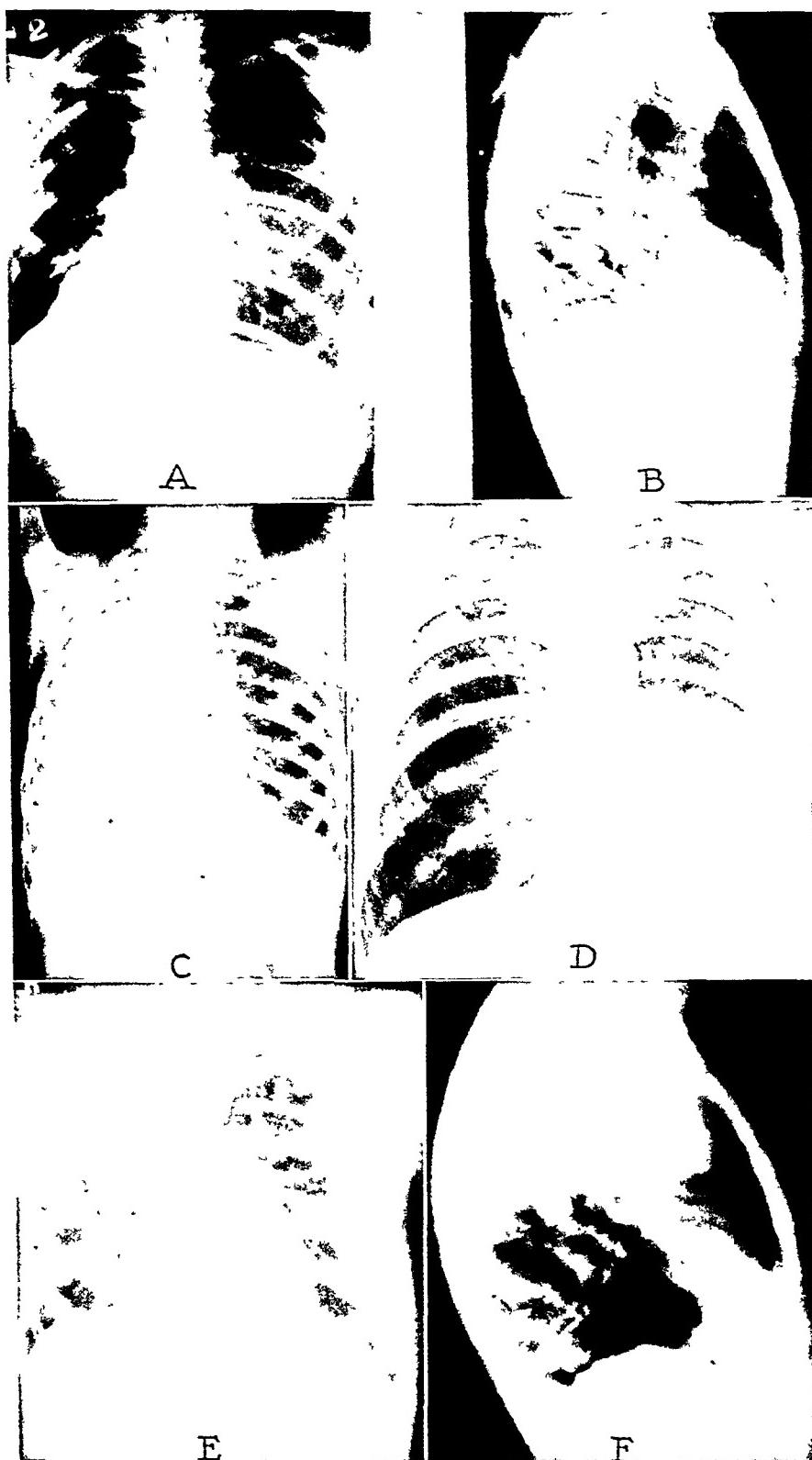
Fig. 10. Complete bronchial obstruction resulting in atelectasis. (A) antero-
posterior and (B) right lateral views of a patient who aspirated a rivet. It is
visualized in the right lower lobe bronchus and has caused a complete
bronchial obstruction and atelectasis. The typical roentgen findings of
atelectasis are illustrated by this and the other three cases shown. Note
the density of the area distal to the obstruction, the elevation of the dia-
phragm on the involved side, and the shift of the mediastinal structures
toward the involved side in each instance. c, four-year-old girl with
atelectasis of the right lung due to a tuberculoma in the right main bron-
chus. D, atelectasis of the left lower lobe due to a bronchogenic carcinoma.
E, atelectasis of the right upper lobe due to complete obstruction of the
bronchus by a carcinoma. The configuration of the involved lobe is well
illustrated in the lateral projection. F, histologic examination of tissue re-
moved bronchoscopically established the diagnosis in each of the last
three cases.

in establishing the presence of a bronchial obstruction.

BRONCHOSCOPY

In recent years bronchoscopy has become a universally accepted procedure. The bronchoscope has come to be considered a diagnostic instrument or speculum which permits direct inspection of the tracheobronchial tree of a patient of any age. Indications for bronchoscopy, which were formerly limited to the extraction of foreign bodies, have broadened so that now bronchoscopy is a routine aid in both the diagnosis and treatment of bronchial obstruction. Foreign bodies, tumors, bronchial compression and cicatricial stenoses produce identical physical and x-ray findings. Consequently, direct inspection must serve to establish the diagnosis of the actual obstructing agent. In the inflammatory diseases dried plaques of mucus, edematous infiltrations or the cicatrix produced by a healing ulcer may be responsible for the findings of obstruction and only the endoscopic view can establish the correct diagnosis. In cases of neoplastic diseases bronchoscopic inspection serves to establish the nature of the lesion through the removal of tissue for biopsy as well as to aid in determining its extent along the bronchial walls. In this respect, bronchoscopic inspection of the upper lobe bronchi and distal portions of the lower lobe bronchi deserves special consideration. Various technical measures are available to the bronchoscopist to make these examinations.[39] The use of retrograde telescopes and bronchoscopic mirrors serves to aid in the inspection of certain portions of the upper lobe bronchi. The use of the biplane fluoroscope to guide curved instruments into the upper lobe bronchi or into distal portions of the lower lobes facilitates the removal of tissue from those areas if they cannot be inspected directly. The use of artificial pneumothorax to bring an upper lobe bronchus into a more direct line with the main bronchus is of extreme value

when an upper lobe bronchus is obstructed by a lesion suspected of being a neoplasm

DIFFERENTIAL DIAGNOSIS

Since a bronchial obstruction is dependent upon some underlying pathology due to a host of etiologic factors, the final diagnosis must be that of the underlying pathology. The differential diagnosis of bronchial obstruction, *per se*, consists of a consideration of those lesions simulating the effects of partial or complete obstruction. In the first category, bronchial asthma and pulmonary emphysema assume an important rôle because they both often closely simulate diseases due to bronchial obstruction. Possibly even more significant is the frequency with which a true bronchial obstruction is considered a simple asthma. The confusing factor most frequently is the wheeze produced by an obstruction which is asthmatic in character. It differs from an asthmatic wheeze, however, because the latter is usually altered at least temporarily on cough, and is expiratory in nature. The wheeze of bronchial obstruction is uninfluenced by cough and is inspiratory in character. In questionable cases, bronchoscopy and bronchography lead to a final diagnosis.

Lesions simulating the effects of complete bronchial obstruction or atelectasis are more numerous and consist essentially of pneumonic consolidation, empyema and tumors. Tumors large enough to give physical evidence of pulmonary pathological conditions may usually be recognized as such by their roentgen configuration. They are, of course, not infrequently involved in a process producing bronchial obstruction, when their differentiation from the atelectasis they have produced becomes almost impossible. Planography and overexposed roentgen films may aid in such differentiation, and again bronchoscopy and bronchography are indispensable.

Atelectasis is most frequently confused with intrapleural collections of fluid. A persistent atelectasis having had an acute

onset closely simulates a pneumonia followed by empyema. The actual differentiation depends on the position of the heart and mediastinum, fluid causing them to be pushed away from the involved side and atelectasis drawing them toward the affected side. The shifting dulness of fluid is another differentiating point. Since an empyema may follow an acute bronchial obstruction, however, the actual diagnosis may be made only after the fluid is withdrawn and the lung fails to expand.

The differentiation of an acute pneumonic consolidation from an acute atelectasis is usually dependent upon the history and the size of the involved lung in relation to its normal size. Postoperative massive collapse of the lung is frequently confused with postoperative pneumonia, but a careful physical and roentgen study of the position of the heart will be the most important distinguishing characteristic. Added difficulty is encountered, however, in cases of complete bronchial obstruction upon which is superimposed a severe suppurative infection to produce a "drowned lung". In this case the products of suppuration so completely fill the bronchi and lung distal to the obstruction that it retains its normal size and shape, yet has the physical and roentgen findings of consolidation. Differentiation in such a case may be made only through a history suggestive of bronchial obstruction, a failure of the pneumonic process to subside and the inspection of the involved bronchus with a bronchoscope.[40]

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FOREIGN BODIES IN THE LUNG

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FROM the viewpoint of thoracic surgery foreign bodies in the lung fall naturally into two very different classes: inspirated foreign body and penetrating foreign body. This is no quodlibetic distinction; the two classes are entirely different in almost every clinical feature.

PENETRATING FOREIGN BODY

In most instances foreign bodies entering the lung by any route other than the natural passages are projectiles. These cases usually call for care by the surgeon.

In case of small penetrating projectiles, however, if it is decided advisable to remove the intruder and there is no indication for opening the chest other than for removal, the foreign body can be removed through the mouth by bronchoscopy. The limit is the size of the foreign body; this limit is imposed by the size of the bronchus tributary to the invaded lobe.[2]

If the projectile has come to rest in a bronchus, removal is quite simple. If, however, the missile has lodged in parenchymal tissue, the biplane fluoroscope and penetrating forceps will be required at bronchoscopy. This procedure is almost always advisable when there are any indications that fabric of any kind has been carried in by the penetrating object, because in such cases suppuration is inevitable no matter how small the foreign body. Anyway, bronchoscopic removal is relatively such a minor procedure that no hesitation should be felt in advising it. Diagnostic bronchoscopy is advisable in all cases of projectile in the lung, no matter how large the intruder may be, to determine local conditions. Hemorrhage from a gunshot wound of one lung may be controlled by packing the tributary bronchus with bismuth subnitrate.[2]

INSPIRATED FOREIGN BODY IN THE LUNG

Foreign bodies reaching the lung by the natural passages constitute a class of case that has been, as stated by the late W. W. Keen, "entirely revolutionized by bronchoscopy." It may be added that the revolution concerns diagnosis as well as treatment. It is a platitude to say that the diagnosis of radiopaque foreign bodies has been revolutionized by the roentgen ray; but it may be added that the bronchoscopist and the radiologist in collaboration have made discoveries that have revolutionized the whole subject of diagnosis of pulmonary disease, including the interpretation of physical signs.[2,3,4] These matters concern chiefly the subject of bronchial obstruction which is covered by the article of Paul Holinger on other pages in this issue of the American Journal of Surgery.

TREATMENT OF FOREIGN BODY IN THE LUNG

All inspirated foreign bodies other than those minute particles concerned in pneumonoconiosis should be removed. In the days when removal of bronchially lodged foreign bodies involved thoracotomy there was ample ground for discussing advisability of removal; but in these days, when almost any localizable foreign body that has entered the lung by natural passages can be removed by the same route, it is unjustifiable to delay for encystment which is a remote possibility, or suppuration, which is a certainty.[2,4]

Emergency Cases. The most urgent and dangerous emergency occurring in cases of foreign body in the air passages is impending asphyxia. It therefore requires primary consideration.

Impending Asphyxia. When a foreign body, such as a bolus of meat or a large toy

is impacted in the laryngopharynx, or in the larynx itself, it not only obstructs the entrance of air, but unfortunately it permits escape of air past the foreign body on expiration. The effect of this one-way valvular action is that the normal thoracic movements are not only unable to draw in air, but *they actually pump air out of the lung*. The thus created bilateral atelectasis is so sudden and complete that it is always fatal, unless a physician happens to be present when the accident occurs.

The symptoms in such a case resemble those of an epileptic seizure in that the patient falls unconscious and is livid in color. The distinguishing features are (*a*) though the patient may clutch at his throat, there are no true convulsive movements of the extremities; (*b*) when unconsciousness supervenes the patient is motionless; and (*c*) there is indrawing at the guttural fossa.

When these three differential diagnostic points are observed the physician should not hesitate to do an emergency tracheotomy.[1] Artificial respiration will be necessary if respiratory movements have ceased. If the patient is intoxicated as is often the case, the artificial respiration may have to be kept up for a considerable time before the patient can be trusted to do his own breathing. In such cases oxygen, if promptly available, is invaluable. Still better in all cases of impending asphyxia is oxygen with carbon dioxide, 5 or 7 per cent admixture, a fact established by Yandell Henderson.

The emergency of impending asphyxia having been eliminated by tracheotomy the foreign body, such as meat impacted in the laryngopharynx, or a toy in the larynx, is then to be removed through natural passages, by direct laryngoscopy.

It might be thought that instead of doing the tracheotomy in case of pharyngeal impaction of such a foreign body as a large mass of meat, the physician could remove the obstructive mass with the finger and thus obviate a tracheotomy. This may be possible in some cases, but usually the efforts at digital removal increase the

impaction, and the thus delayed tracheotomy may be too late.

Of course, if endoscopic means of removal are set up and ready a facile endoscopist could in a few seconds remove the obstruction, insert a bronchoscope through the mouth and resuscitate the patient by bronchoscopic insufflation of oxygen (plus carbon dioxide); but we are discussing here the emergencies that confront the practitioner. Every physician is, or should be able to do promptly a two-step, finger-guided emergency tracheotomy.[1,2]

The cardinal signs of obstructive laryngeal dyspnea calling for tracheotomy are as follows:[1,2] (1) Indrawing at the suprasternal notch; (2) indrawing around the clavicle; (3) indrawing of the intercostal spaces; (4) indrawing at the epigastrium forming a "funnel breast"; (5) restlessness; (6) choking and waking as soon as the aid of the voluntary respiratory muscles ceases in falling to sleep; (7) ashy color of the face, and (8) cyanosis is a dangerously late symptom.

Potential Asphyxia. A patient with a foreign body may be apparently perfectly normal yet be in danger of onset of asphyxia.

No consideration of the subject of emergencies in case of foreign body in the lung would be complete without a warning against the *symptomless interval.*[2] In our records are innumerable instances of a child dismissed with a negative opinion as to presence of a foreign body because of absence of symptoms at the time of examination. It does not seem to be realized generally that a foreign body can be lodged in a bronchus and yet the child be happy and playful, without cough or any obvious abnormality. Yet our clinical records show that in nearly 80 per cent of the cases of foreign body there was, after the initial gagging and choking, a symptomless interval varying in duration from a few hours in case of a bean or a peanut to a few months in case of a pin or needle. We have notes of many cases of a child dying of asphyxia on the way to our clinic. In a number of such

cases the child after an attack of choking and gagging on some foreign substance had been taken to a physician who had found "nothing wrong with the child." After a symptomless interval alarming symptoms developed and the patient died on the way to the hospital. The mechanism in such cases was of three kinds:

A. In some such cases an inspirated foreign body such as an orange seed was coughed loose and was impacted in the glottis.

B. In other cases a large foreign body, such as a half peanut kernel, turned crosswise at the bifurcation, obstructing ingress of air into both lungs; lifting on expiration it really acted as a one-way valve pumping air out of both lungs; asphyxia in such cases was sudden.

C. Quite frequently the asphyxia was due to increase in size of a tracheally or bronchially lodged foreign body, by its swelling, together with narrowing of the passages by mucosal swelling. This combination occurs always with dried beans and maize, and often with other bodies. These substances, swell enormously from absorption of water and, like all vegetal foreign bodies, cause a fulminating reaction in the tracheobronchial mucosa, the intensity being inversely as the age of the child. It takes very little swelling of the mucosa to narrow the airway in the small bronchi of children.[2,5]

In these cases of symptomless interval, the apparently normal, even playful behavior of the child gives no warning of the desperate impending asphyxia that may supervene suddenly a few hours later when the airway is occluded by the swelling of the foreign body and the mucosa. Of course, the greatest danger and urgency is in cases of foreign body in the trachea or at the bifurcation. Occlusion of one main bronchus does not cause dyspnea so long as the foreign body remains fixed. If, however, even in such a case the foreign body should be coughed loose, it is almost certain to be inspirated into and occlude the other main bronchus. Immediate asphyxia usually follows lodgment, because the previously obstructed lung being more or less atelectatic does not immediately resume function.[4]

BRONCHOSCOPY FOR FOREIGN BODY

In the foregoing we have considered the emergencies incidental to foreign body in the lung or obstructing the airway leading thereto. As a matter of fact, however, relatively few of the total number of cases of foreign body in the airway constitute emergencies.

Nonobstructive metallic foreign bodies such as needles, pins, small tacks, screws and nails in the tracheobronchial tree, do not constitute an emergency. The lungs are remarkably tolerant of such objects as long as they are not greatly obstructive. The barrier of the mucosa and bronchial wall is powerfully resistant to infection as long as ventilation and drainage are maintained.[5] In fact, iron and steel objects have an inhibitory effect on suppurative infections, probably by ionization. When there is obstruction to ventilation and drainage, however, suppuration will supervene. Even in such cases, there is no emergency. It will take weeks, in case of pins and needles months, for suppuration to get started, and even longer before the bronchial walls break down and abscess forms. There is, therefore, no justification for precipitate procedure. A well planned and carefully executed peroral bronchoscopic procedure will be successful in close to 100 per cent of the cases of inspirated foreign body.

Technic of Bronchoscopic Foreign Body Removal. The technic of insertion of the bronchoscope is easily acquired by competent instruction and training; the removal of a foreign body is, however, in many instances a highly technical, complicated procedure fraught with pitfalls and difficulties that may greatly endanger the patient's life. Adequate consideration of these technicalities is beyond the scope of a magazine article. They are fully considered in standard textbooks.

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THE disturbances caused by abnormally situated thyroid lobes are dependent almost entirely upon the mechanical displacement of organs native to this region. . . . The organs involved are the trachea, the esophagus, the blood vessels, and the nerves.

THE brief excerpts in this issue have been taken from "Diseases of the Thyroid Gland" by Arthur E. Hertzler (C. V. Mosby Company).

RECENT DEVELOPMENTS IN SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

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INTRODUCTION

IN approaching the subject of recent developments in any field of surgical endeavor, it behooves one to review the historical background upon which rests the accepted philosophy of today. Of value are the records of past mistakes, that one may know what to avoid. Of even greater value, are the enduring truths that guide one into safer paths. Therefore, the historical approach, although of necessity in greatly condensed form, is employed in this discussion. Those who would delve further into this fascinating field should consult Murphy,[1] Sauerbruch,[2] Alexander,[3,4] Graham, Singer and Ballon,[5] and in particular, the writings and the discussions of Willy Meyer, which are replete with illuminative historical references, the accuracy of which cannot be questioned.

The discussion aims to trace the evolution of the philosophy of surgical treatment from the first serious efforts of the closing decades of the last century, through and including the thoughts expressed in the more important meetings of 1941. Details of technic, tabulations of indications and contraindications have, for the most part, been excluded. All those topics can be found readily in the literature. The viewpoint is that of a general surgeon; that of an individual.

Historically, three periods are recognized: the early period, the period of collapse therapy by trial and error and the period of rationalized collapse therapy. More or less arbitrary limits have been adopted. The first period embraces the last three decades of the nineteenth century. The second period embraces the first three decades of the present century. The third period dates from 1930.

Certain premises have been postulated, some purely surgical, others of broader implication:

First Premise. Rest under sound medical supervision, remains the unshaken cornerstone of treatment for pulmonary tuberculosis.

Second Premise. Pulmonary tuberculosis never was and never will be a "surgical disease." Operative intervention will prove beneficial to a fraction only, of all patients, and properly, therefore, is applicable to a fraction only.

Third Premise. The whole subject of surgical treatment of pulmonary tuberculosis is still in an evolutionary stage. Few, if any, "final words" have been written. There is vast room for improvement in every aspect of the work.

Fourth Premise. The practice of surgery includes the application of ten or more specific basic policies. Three of these basic policies are now, or have been at some time, utilized in the surgical treatment of pulmonary tuberculosis. They are: (1) the policy of total extirpation; (2) the policy of drainage, and (3) the policy of indirect surgery. Total extirpation is one of the most powerful weapons at the disposal of the surgeon. Drainage is likewise a powerful weapon. Indirect surgical attack is a very weak weapon, possibly surgery's weakest weapon.

EARLY PERIOD

Anesthesia, antisepsis and asepsis paved the way for the renaissance of surgery during the eighth decade of the nineteenth century. Experimental and clinical surgery advanced at a rapid pace. It was the day

of direct surgical attack: total extirpation, drainage, plastic operations, anastomoses, such similar procedures. The abdomen, the cranium, the thorax were all entered. The results of direct surgical attack for abdominal disease were definitely encouraging, and in that decade were laid the foundations of many a modern abdominal operation. Not so, however, in the case of thoracic disease, tuberculous or otherwise. It was soon discovered that the thorax could not be opened with impunity. "Open surgical pneumothorax," with its high rate of asphyxial death, became the deterring factor in intrathoracic surgery and remained so for years to come. Other than the Estlander and Schede operations for chronic empyema, which still survive in somewhat modified form, little if anything has come to us from the decade 1870 to 1880. It is significant that those operations were designed for patients whose mediastina had already become fixed by disease, and who could tolerate extensive operations upon their chest walls without the risk of paradoxical respiration and asphyxial death.

Lobectomy, open drainage, instillation of antiseptics into cavities, were all attempted on tuberculous patients. Sauerbruch,[2] at the 1908 International Tuberculosis Conference at Washington, D. C. referred to the results of these early operations as "worthless." One may fairly assume, in retrospect, that the early experiences were so discouraging that, in the treatment of pulmonary tuberculosis, all direct surgical attacks were abandoned and the general philosophy adopted that such procedures had no legitimate place in the treatment of the disease. This philosophy continued to dominate surgical and medical thought for more than fifty years.

Fortunately, however, the discouragements of the seventies did not deter all efforts. Direct surgical attack gave way to indirect methods. De Cérenville, Spengler, Quincke, Turban, Gourdet and Boiffin during the eighties and nineties were

quietly persevering in the field of surgery. With the Estlander operation for chronic empyema as the prototype, and with a high mortality rate to combat, these early pioneers were groping toward the operation known as thoracoplasty. Forlanini, Potain and Murphy were developing therapeutic pneumothorax. Tuffier accomplished a successful extrapleural, transthoracic resection of a cavity-bearing apex and therewith laid the foundation for the pleurolytic operations. The dawn period of collapse therapy had arrived.

Just where the early experimental period ends and the established collapse therapy period begins, is hard to say. Let it be set arbitrarily at 1903, when Brauer, Friedrich and Sauerbruch all gathered at Marburg and commenced their monumental work on the development of thoracoplasty. One must not, however, assume that the philosophy of collapse therapy had, by that time, become widely accepted. It had not, and it is to be noted that in his Chairman's address before the Surgical Section of that 1908 Conference, C. H. Mayo,[6] keen and alert to surgical progress as he was, made not one reference to surgery as a therapeutic measure for pulmonary tuberculosis. Of forty-three papers on that Section program, only two (Robinson[7] and Sauerbruch[2]) dealt with thoracic surgery.

In rapid summary the results of the early period were:

Direct surgical attack (extirpation and drainage) had been tried, found wanting and discarded.

Therapeutic pneumothorax had been proved feasible. It was still in the experimental stage. It had not become widely accepted.

Multiple costectomy was in the experimental stage. Thoracoplasty, as it is known today, had hardly been visualized.

Parietal pleurolysis had been demonstrated as a method of surgical approach, and was being explored as a procedure of therapeutic value.

Only the hardiest pioneers were attempting any such therapeutic measures.

PERIOD OF COLLAPSE THERAPY
BY TRIAL AND ERROR

At the beginning of this century therapeutic pneumothorax was the only procedure carried out in approximately the same manner as employed today. Thoracoplasty was known, but the operation of 1900 was utterly unlike the operation of 1941, or 1930, or 1920, or even 1910. Pleurolytic operations were occasionally performed. Anesthesia was crude. It did not seriously hamper progress in the abdomen, but it did hamper progress in thoracic work. It was definitely believed that direct surgery had no place in the treatment of pulmonary tuberculosis. Available statistics were meager and discouraging. There were no "trained thoracic surgeons." Only a few general surgeons and internists were seriously interested in exploring the possibilities of this field. Fascinating as it would be to trace the progress of this period in detail, time will permit only brief reference to some of the outstanding events.

It is doubtful if the phrase, "collapse therapy," was in use at the beginning of this period. It is certain that the concept of lung relaxation as recognized today, was not appreciated. Many still believed that resection of the upper ribs allowed the apex of the lung to "expand," become better ventilated and better vascularized. With such concepts, it is obvious that progress had to be achieved by the trial and error method.

The phrase, "collapse therapy," should include all measures, surgical, quasisurgical or mechanical, that will bring about diminution in volume of hemithorax or lung, with consequent physiological rest and increased prospect of healing of the tuberculous focus. "Collapse therapy" should not include drainage, total extirpation or other direct surgical procedures. As in descriptive zoology, so also in describing surgical operations, one may speak of genera, species and varieties. Extirpations or resections fall into one genus, drainage into another, collapse measures into still another genus.

The procedures of collapse therapy may be further divided into three species, depending upon the treatment of the pleural space, the respiratory motor mechanism or the chest wall proper. The last species must be further subdivided, depending on the treatment of the various anatomical components of the chest wall:

1. Diminution of the lung volume by separating the parietal and visceral pleural layers, but without crippling the respiratory motor mechanism or disturbing the chest wall structures. Therapeutic pneumothorax is the type variety of this species.

2. Diminution of lung volume by crippling the respiratory motor mechanism, without necessarily altering pleural or chest wall relationships. Diaphragmatic paralysis is the type variety of this species.

3. Diminution of lung volume by some anatomical alteration of the chest wall, but without necessarily crippling the respiratory motor mechanism or separating the pleural layers. The varieties are so numerous and divergent, that subspecies must be recognized.

3 A. *Diminution of lung volume by diminution of hemithorax volume, by removal of rigid chest wall structures.* Thoracoplasty is the type variety of this subspecies.

3 B. *Diminution of lung volume without diminution of hemithorax volume, by cleavage between chest wall structures regardless of resulting disturbance of blood supply.* The parietal pleurolytic operations are varieties of this subspecies.

3 C. *Miscellaneous limited operations on the chest wall.* A few highly diversified varieties such as subcostal compression, scaleniotomy, etc., have been reported.

By 1900, therapeutic pneumothorax had become a recognized procedure. Adhesions, then as now, defeated many a case. Open thoracotomy, for the section of adhesions, first reported by Friedrich in 1908, resulted in a high mortality rate from empyema. In 1912, Jacobaeus introduced intrapleural pneumonolysis, a much safer procedure.

One smiles when realizing that Jacobaeus turned the laparoscope into a thoracoscope, and very recently others have turned the thoracoscope back into a peritoneoscope. In 1922, Bernou introduced oleothorax.

Tuberculous empyema has been the by-product of therapeutic pneumothorax. Naturally, open drainage was first employed, but the results were not good and the pendulum swung far to the other extreme. Internists, surgeons, pathologists, bacteriologists, all contributed to the clarification of the subject. Alexander[8] has clearly stated the important considerations upon which sound treatment for each individual case may be formulated.

In 1911, Stuertz suggested phrenic nerve surgery. A wave of enthusiasm was followed by a wave of disappointment. In 1913, Friedrich performed intercostal neurectomy. In 1922, two modifications were introduced, phrenic exeresis and the radical dissection of the brachial plexus. Neither of these modifications added to the benefits to be expected. In 1933, Vadja reported pneumoperitoneum. Shot bags, braces, abdominal belts, lateral posture have all been suggested as mechanical adjuncts.

Operations involving chest wall structures early took two divergent paths, one leading toward thoracoplasty by multiple costectomy, the other toward the pleurolytic operations. In the thoracoplasty group, 1903 is a significant year. It marked the beginning of a systematic effort by Brauer, Friedrich and Sauerbruch, at Marburg, to evolve a safe and effective surgical operation for such patients as could not be treated successfully by pneumothorax. At that clinic pneumothorax was the procedure of choice and one is led to assume that only "pneumothorax failures" were referred to surgery. That may have been the basis for the tradition that pneumothorax must be tried and proved a failure before any other method may be attempted.

The experimental and clinical work at Marburg resulted in the operation known as Sauerbruch's extrapleural paravertebral thoracoplasty. For many years it was the standard operation but has now become obsolete. It served the very useful purpose of reducing operative mortality to a figure that encouraged, rather than discouraged further efforts in the field of tuberculosis surgery. Wilms also made important contributions. The principles underlying thoracoplasty were always surgically sound. The modifications that have appeared almost yearly have not altered the basic principles, but have added technical refinements and have incorporated the results of improved judgment.

The pleurolytic operations date back to 1891. Further developments hinged largely on the treatment of the "dead space." In 1901, Sarfert combined parietal pleurolysis with compression gauze packing. In 1910, Tuffier utilized fat plombage. In 1913, Bear employed paraffin. Other materials for plombage purposes, temporary or permanent, include muscle, rubber dam and rubber bags. Finally, air became the filling of choice. The pleurolytic operations have never been unanimously accepted as surgically sound. It is significant that they have waxed and waned in popularity.

The importance of anesthesia cannot be overemphasized. New agents, including the anesthetic gases, and great improvements in the technic of administration, have been significant factors in surgical progress.

It is characteristic that in the course of early surgical efforts, technic receives more attention than function or pathology. Mechanical execution excels judgment. Explanations for failure are sought first in methods of procedure, later in the laws of physiology and pathology. During the period of collapse therapy by trial and error there was a great accumulation of disjointed findings relating chiefly to technic. Years of careful study and correlation with the facts of physiology and pathology will be required to weld these discreet observations into one perfect composition. That task becomes the dominant theme of the period of rationalized therapy.

To refer to a period of trial and error does not mean that there were no great thinkers. Prophets are always with us. The prophets of one generation lay the foundation for the accepted work of the next generation. Not the prophets, but the rank and file determine the level of a given age.

In summary, the period of collapse therapy by trial and error saw: A world-wide awakening to the possibilities of surgical help for those suffering from pulmonary tuberculosis; a host of new operations introduced, some ephemeral, some of lasting value; great strides in technical improvement, but relatively little advance in precise diagnostic methods; extremely important improvements in the technic of anesthesia. General surgeons with special interest in thoracic work, co-operating with phthisiologists, were the clinical leaders of the period. Pathologists, physiologists and particularly workers in surgical research laboratories commenced an increasing volume of fundamental scientific investigation.

PERIOD OF RATIONALIZED COLLAPSE THERAPY

The beginning of rationalized collapse therapy may be arbitrarily placed at 1930. Two factors help in determining that date; the more important, the appearance of trained thoracic surgeons, the other, improvement in precise diagnostic methods and the continuation of research. The progress of the present period will be considered under the headings of training, diagnostic procedures, technical procedures, the optimum surgical environment and the effect on the philosophy of treatment.

Training. The pioneers who laid the foundation for thoracic surgery, including collapse therapy, were general surgeons and internists. They were not specially trained in thoracic problems. This was just as true of New World pioneers as of their Old World predecessors. Now special training in thoracic surgery can be secured.

There are a limited number of approved residencies. Highly developed postgraduate training is offered by several universities in the United States and Canada. Eggers,[9] Graham,[10] Alexander[11] and Packard,[12] gave a clear pronouncement in 1936 that basic training in general surgery should precede all training in thoracic surgery. A committee of the American Association for Thoracic Surgery[13] further pronounced in 1937 that there is little likelihood that competent certification will be issued to the thoracic surgeon, other than certification in general surgery. This was reiterated in 1941.[14]

Year by year names are added to the list of men soundly trained in the fundamentals of surgery and the refinements of thoracic work. The effect of such a supply of competent surgeons can be predicated with a fair degree of accuracy: Sound logic will replace empiric effort; the demand for better diagnostic study will increase; the selection of cases for operation will be more intelligent; the quality of surgical care will improve; the variety of surgery will be broadened; a better grade of anesthesia will be demanded, and the environment in which the surgery is done will be improved.

Diagnostic Procedures. Diagnostic methods have been modified, during the last decade, in three very important particulars. These modifications are: the utilization of bronchoscopy, improvements in roentgenologic technic and the development of bronchospirometry. Other improvements have also been made.

Bronchoscopy, until approximately 1930, was regarded as definitely contraindicated by pulmonary tuberculosis; now it is not only permissible but usually desirable. Bronchoscopy has opened the way for the accurate study of the life history of tuberculous bronchitis. In connection with this very important subject one is referred to the writings of Barnwell, Littig and Culp,[15] Eloesser,[16] Samson and Culp,[17] Warren, Hammond and Tuttle,[18] Myerson,[19] Riggins,[20] and to the more recent symposium at the 1941 annual meeting of the

American Association for Thoracic Surgery by Chamberlain and Gordon,[21] Tuttle,[22] Alexander, Sommer and Ehler.[23] The gist of these contributions is to the effect that acute hyperplastic or ulcerative tuberculous bronchitis is a very serious complication, that it leads to bronchostenosis in a very high percentage of its victims and that bronchostenosis leads to severe secondary pulmonary suppuration. It has been demonstrated that the condition can be diagnosed and evidence is accumulating to show that all questionable cases should be bronchoscopically examined before instituting definitive treatment. Tuberculous laryngitis is, however, a valid contraindication to such examination.

Roentgenographic studies remain important. The recent development of tomography or laminography (let us hope that the arbiters of roentgenologic terminology will soon give us one acceptable term) is the most significant forward step.

Bronchospirometry or bronchospirography is the newest effort in precise diagnosis. Jacobaeus[24] gave an early report in 1937. Pinner, Leiner and Zavod[25] presented a scholarly review of this functional test in 1941. Some extraordinarily interesting observations have been made. The vast expanse of this field has not yet been glimpsed, but one may predict that the time will come when an estimate of respiratory function will be considered practical and important.

Sputum examination by refined methods, including identification of the tubercle bacillus by culture, has influenced the classification of surgical end results. It is no longer sufficient for sputum to be negative on direct smear; the day will arrive when it will no longer be sufficient for it to be negative on concentration; negative animal inoculations, negative cultures and negative gastric contents will be required.

Technical Procedures. Progress in technical procedures includes important modifications in thoracoplasty, air as a filling substance in pleurolytic operations, the reintroduction of drainage and extirpation operations and great improvement in anesthesia.

The extrafascial apicolysis of Semb is a distinct contribution. It is an anatomically precise dissection of all apical structures from their cervical and upper mediastinal relationships. It is surgically sound in that it is accomplished under direct visual control. It provides additional valuable caudad relaxation. But it adds to the hazards of thoracoplasty and therefore must be utilized judiciously. Gale and Oatway[26] have presented an excellent critical evaluation.

Aycock, Brantigan and Welch[27] have reported the clever utilization of a subpectoral air cushion in his so-called "extrafascial pneumothorax." It helps stabilize a flaccid chest wall, and adds an element of compression to the relaxation ordinarily obtained by thoracoplasty. Of necessity, it entails a large dead space which is an obvious disadvantage.

Proctor[28] has presented a careful study of "extrapleural pneumothorax," the newest variety of pleurolytic operation. Air is the filling substance, and air is well tolerated. One does not gain the impression, however, that this pleurolytic procedure will supplant the safer thoracoplasty.

Open drainage was early employed and rapidly fell into disrepute. In 1938, however, new interest was added to the subject by the report of Monaldi's closed drainage with gentle suction. Apparently drainage operations have returned upon a rationalized basis. There is much to make one pause and carefully reconsider the whole subject. One should consult Kupka and Bennett[29] for full details.

There is also the subject of palliative open drainage of the huge cavities with luxuriant growth of pyogenic organisms, by-products of tuberculous bronchostenosis. An authoritative pronouncement, based on a clear restatement of fundamental mechanical, physiologic and pathologic factors relative to the utilization of drainage is greatly needed. In the meantime it can only be said that the treatment of pulmonary tuberculosis will not be revolu-

tionized by drainage, and that one should proceed with the utmost caution.

Occasional case reports of pneumonectomy and lobectomy for pulmonary tuberculosis have appeared from time to time. The experiences of Dolley and Jones,[30] reported in 1940, provoked discussion that resulted in the tabulation of all available cases in the United States and Canada. The summary of the 1940 poll gave the following figures:

| | Pneumonectomy | Lobectomy | Totals | |
			No.	Per Cent
Apparently well..	3	16	19	38
Improved........	6	6	12	24
Unchanged.......	0	1	1	2
Worse...........	2	0	2	4
Dead...........	8	8	16	32
	19	31	50	100

Improvements in technic and in anesthesia have reduced mortality and have enabled 62 per cent of the patients to become arrested or improved. Operations of extirpation have, therefore, been reintroduced on a vastly sounder basis than sixty years ago. But the indications have not yet been clearly formulated.

Anesthesia, as an art and as a science, has advanced rapidly. The most important new agent is cyclopropane. The most significant achievement is the apnea technic. These improvements in anesthesia may prove to be the most important advances of the past decade.

Surgical Environment. Surgery, such as has been described, requires an environment that conforms in all respects to the established standards of American surgery. In particular, there must be assured: adequacy and competency of personnel, facilities for expert anesthesia, adequacy of equipment, facilities for expert surgical nursing, competent supporting laboratory and roentgenologic services and assurance

that unhampered surgical judgment will control all clinical activities. This conformity to American surgical standards, upon which rests the moral right to maintain such a surgical program, is of paramount importance and supersedes all other considerations.

If such a surgical environment can be created within institutions primarily devoted to the care of the tuberculous patient, so much the better. Two great advantages, expert surgery and expert tuberculosis nursing and care, will thereby be secured for the patients. If such a surgical environment cannot be created within institutions devoted to the care of the tuberculous patient, then, on moral grounds, the patients should be transferred elsewhere for their surgical program.

Philosophy of Treatment. The generally accepted philosophy of treatment of pulmonary tuberculosis, if there ever has been such, has been built around the one word "rest." But instead of a coherent philosophy, one might prefer to recognize a series of independent concepts. Some of these concepts rest on a sound factual foundation and come to us with the weight of scientific truth. Other concepts rest on reasonable hypotheses and claim our respect, pending final verification or refutation. But some concepts appear to rest on tradition only and to be no more than blind formulae. The advent of men well trained in all the aspects of thoracic disease is certain to affect profoundly the philosophy of treatment. These trained men will challenge every concept of therapy. In their minds, the validity or nonvalidity of the concept will be determined, not by its venerability or legality, but by its conformity to basic natural law.

At present, two concepts remain unshaken: The first, that rest is the sheet anchor of treatment; the other, that proper institutional care is of inestimable advantage to the patient. All other concepts are being subjected to rigid scrutiny, and, one by one, must stand or fall on the basis of their own merit.

The concept that ether may not be used as an anesthetic has fallen. The concept that pulmonary tuberculosis is a valid contraindication to bronchoscopy has been refuted. The concept that direct surgery has no legitimate place in the treatment of pulmonary tuberculosis has been sharply challenged, if not actually refuted. The concept that therapeutic pneumothorax must be the first effort has been sharply challenged. Other old concepts have been questioned. New concepts are in process of formulation.

One hears more frequently the phrases, "reversible therapy" and "irreversible therapy," occasionally the phrases, "reversible pathology" and "irreversible pathology." It has long been accepted that "reversible pathology" should be treated by "reversible therapy." It has not been universally accepted that "irreversible pathology" should receive "irreversible therapy." However, a healthy doubt is rising in the minds of many as to whether a "reversible" therapeutic procedure has any logical place in the scheme of treatment of an "irreversible" lesion.

The general management of pleural complications has been quite thoroughly explored. Sound surgical recommendations have been formulated, but have not been universally accepted by other interests. There are still glaring examples of mismanagement.

It yet remains to formulate a sound therapeutic program for the unfortunate victims of tuberculous bronchitis, acute or chronic. More cases must be studied; more statistics must be compiled; more thought must be expended; more truths must be determined; more courage must be developed. Above all, sound clinical judgment must control the destinies of these unhappy people.

The surgeon looks at pneumothorax and thoracoplasty and thoughtfully reflects that they are the undisputed seniors in the ranks of collapse procedures. They have earned their right to a permanent place and one may confidently expect them to survive as long as surgery has a place in the treatment of pulmonary tuberculosis. They are alike in that they offer more effective collapse than any other measures; they are unlike in that one is reversible, the other irreversible; and further they are unlike in that one offers 70 to 75 per cent prospect of success and the other, today, offers 70 to 75 per cent prospect of failure.

The surgeon looks at the phrenic nerve operations and the pleurolytic operations and sees, at best, weak efforts, and, therefore, efforts to be used infrequently.

The surgeon looks at drainage operations and begins to see great possibilities, but also risks.

The surgeon looks at lobectomy and pneumonectomy and sees still greater possibilities, but also greater risks. He sees the need of rigid rules and requirements that would exclude all but 1 per cent or so of patients with pulmonary tuberculosis from such procedures. No extirpation operation should be done except with the moral certainty that the contemplated operation will remove all foci of active tuberculosis.

The surgeon looks at the whole field of therapy and sees evidence of sounder clinical judgment, better technical skill and more satisfying end results.

The older surgeon looks at his younger brother fresh from a thorough drilling in the basic sciences and says: "Yours is the task to sift and sift, to save the truth, to destroy the false, and to evolve a philosophy of treatment that will conform to natural and spiritual laws as they were created and have existed since the beginning of time."

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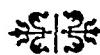
EMERGENCY TREATMENT OF PULMONARY HEMORRHAGE IN THE TUBERCULOUS PATIENT

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HEMOPTYSIS is a common symptom in pulmonary tuberculosis occurring in about 50 per cent of all cases at some time during the course of their disease. Various observers give figures varying from 20 to 80 per cent of cases, depending upon the stage of the disease, however, it is more common in the advanced cavernous type and usually is more extensive in this type of disease. It is the terminal event in a very small percentage of cases. About 1 or 2 per cent of patients will die as a direct and immediate result of a profuse pulmonary hemorrhage. It is extremely rare for a patient to die from the loss of blood *per se* but it is not uncommon for a patient to drown or suffocate in his own blood. The amount of bleeding also varies within wide limits from blood streaked sputum to massive hemorrhages of a quart or more, and it should be pointed out that the amount of blood expectorated is not an absolute index of the amount of bleeding that has occurred. There is almost always some blood retained in the lungs. In rare instances, more blood is retained in the lungs than is expelled.

In a general way there are three types of bleeding in pulmonary tuberculosis: When the blood occurs in streaks or as blood tinged sputum the cause is probably a capillary ooze from hyperemic areas or from the bronchial mucosa. The more common form is caused by an erosion or ulceration of a blood vessel by the actual tuberculous process. This is the usual cause in those cases in which we see from a teaspoonful to several ounces of pure blood expectorated, and is the type that may recur at varying intervals. Most profuse hemorrhages are brought about by destruc-tion of lung tissue which leaves the blood vessel unsupported so that it ruptures, or aneurysmal dilitation occurs which later ruptures, giving rise to massive and at times, uncontrollable hemorrhages. There are other, rarer forms of bleeding that occur in tuberculosis without parenchymal disease. The most common of these are bleeding from ulceration of the bronchus and bleeding from the breakdown and ulceration of a hilum gland.

Hemoptysis is an alarming symptom both to the patient and to the physician; and even though it is rarely immediately fatal, it is often the beginning of a steady and rapid downhill course. In most instances, the after effects are more to be dreaded than the actual bleeding.

In the therapy of this symptom, there are a few fundamental principles to be followed: The first duties in treating this symptom are to put the patient at rest and do everything possible to allay his nervousness. Undoubtedly, nervousness and excitement on the part of the patient tend to increase the bleeding or to displace a blood clot that may be forming. Absolute rest should be enforced.

In approaching the treatment of this symptom, the first problem with which one is faced is the source of bleeding. In other words, has the patient been previously studied so that the most likely source of bleeding is known at the time that it occurs? Next, the therapeutic approach should vary somewhat with the extent of bleeding, namely, is it minimal, moderate or massive? In all pulmonary hemorrhages the patient should be put at absolute rest and reassured. Small hemorrhages usually stop of themselves without any treatment.

There is some divergence of opinion as to the position in which the patient should be placed. In my opinion, this is dependent, to a large extent, upon the above mentioned factors, namely, is the site of bleeding known, and second, is the extent of the bleeding slight or moderate, severe or massive? If the bleeding is slight to moderate and its source is not known, the patient should be placed in a semi-Fowler position. If the side of the bleeding is known, he should be turned on the bleeding side. If the bleeding is severe and the side is not known, and it cannot be determined, the patient should be placed flat on his abdomen with the foot of the bed elevated. If the side of the bleeding is known and the hemorrhage is severe or massive, the patient should be laid in the prone position, partially rotated with the bleeding side down. This will tend to splint the bleeding lung, will aid in postural drainage and will prevent aspiration of blood and bacilli laden sputum to the contralateral lung.

Mild sedation is indicated in practically every case. Sedatives should be used to the extent of quieting the cough but not to stop it and to allay the nervousness and excitement of the patient. Small doses of codeine, such as $\frac{1}{4}$ gr. every three hours in conjunction with the bromides and barbiturates are usually adequate. The stronger opiates, if used at all, should be used in very small doses. They reduce the cough reflex to such a point that they predispose to the retention of blood in the lungs with a subsequent development of atelectasis and tuberculous or pyogenic bronchopneumonia.

After the institution of absolute rest and mild sedation, the next problem to be faced is, can the bleeding be controlled medically or should surgical or mechanical means be resorted to? Medical treatment, at best, is not very satisfactory. The number of remedies which have been suggested and used, many of them with diametrically opposite action, will indicate that we have no certain methods of arresting the bleeding from the lungs, and, also, that the medical profession, realizing its impotence,

is still ready to grasp any straw which offers any hope of success.

The various drugs that have been recommended fall into two main groups: those which affect the circulation and those which increase the coagulability of the blood. In spite of the enthusiastic reports of many, most of these drugs are of little or no value; however, some of these should be mentioned. Atropine sulfate is thought by some to be of considerable benefit and may be given in doses of $\frac{1}{100}$ gr. (0.6 mg.) hypodermically. The nitrites have been recommended because they lower the systemic blood pressure and in that way may lower the blood pressure in the pulmonary circulation. They may be given in the form of amyl nitrite, nitroglycerin or sodium nitrite. Ergot was formerly used to a large extent but it actually causes a rise in pulmonary blood pressure and for this reason cannot be recommended. Emetine is considered by some to be almost a specific in moderate or even severe types of pulmonary hemorrhage. It may be given in the form of emetine hydrochloride in 1 gr. (0.065 Gm.) doses hypodermically. Beneficial effects may be due to dilitation of the splanchnic vessels with reduction in the pulmonary blood pressure.

Drugs which purportedly influence the coagulability of the blood, have been tried extensively. Calcium in the form of calcium lactate or gluconate by mouth has been used for many years, but it has no demonstrable effect on bleeding unless given in massive doses. It has been highly recommended as a placebo that does no harm. Calcium gluconate given intravenously, is thought by some to be of value, and it is suggested that viosterol be administered at the same time to make certain of increasing the blood calcium, which is essential to the process of coagulation.

Coagulants, such as fibrogen, thromboplastin, etc., are of value in reducing the coagulation time and may be of some benefit in treatment, provided it has been shown by laboratory tests that altered coagulation is a factor in the bleeding.

The intravenous use of Congo red has been highly recommended as a treatment for hemoptysis. Ten cc. of a 1 per cent solution given daily for several doses has been recommended. It is supposed to reduce the clotting time, increase the blood platelets and the blood fibrin content. In my somewhat limited experience, it has been of little value; and when one considers the pathologic condition of tuberculous hemoptysis, that is, bleeding from a blood vessel with infiltrated and degenerative walls, it is easy to see how little can be expected from a hemostatic. The use of various vitamins has been suggested particularly vitamin c and vitamin κ. They are of no proved value unless there is a know vitamin deficiency. Snake venom has been recommended in recurring hemoptysis but, in my opinion, there is little justification for its use.

In contradistinction to the above measures, the mechanical means of controlling pulmonary hemorrhage offer the double advantage of controlling the bleeding as well as the underlying disease. Of the various procedures, pneumothorax is the one of choice. In considering collapse therapy for pulmonary hemorrhage, it is, of course, necessary to know from which side the hemorrhage is coming. This may be very difficult as the tuberculous lesion may be bilateral and may possibly have open cavities in both lungs as likely sources of bleeding. Physical signs are of value in determining which side is bleeding, but may on rare occasions be misleading due to aspirated blood. Quite often the patient can tell, with fair accuracy, the side from which the blood is coming. This type of case should be approached with great caution. It has been my practice to put off attempting pneumothorax until I could be relatively sure as to the source of bleeding. Hemoptysis, in my opinion, is the one indication for rapid induction of pneumothorax. By this method 500 to 1,000 cc. of air are instilled at the initial treatment and a refill is given within twelve to twenty-four hours and thereafter as often as needed,

dependent upon the control of the hemorrhage and the type of collapse obtained. In my opinion, except in rare instances, positive pressure should not be given on the initial treatment. Theoretically, pneumothorax is the ideal treatment for pulmonary hemorrhage; but from a practical viewpoint, a satisfactory collapse frequently cannot be induced due either to the absence of free pleural space or the presence of extensive adhesions, which prevent collapse of that portion of the lung from which the bleeding is coming. With prompt recognition of this complication by early thoracoscopic examination, one can occasionally convert an unsatisfactory pneumothorax into a satisfactory one. This procedure may appear radical, but in my experience has given good results in a few cases in which it was resorted to.

In cases in which there is no free pleural space, phrenic nerve interruption has been of value in at least temporarily controlling hemorrhages. In a few instances we have supplemented phrenic nerve interruption with pneumoperitoneum, with satisfactory results. There are some cases of recurring pulmonary hemorrhage in which pneumothorax and phrenic interruption have failed to control the bleeding; in these instances thoracoplasty is indicated. This procedure is justified only in those cases in which the bleeding is reasonably well controlled on rest, but recurs on the slightest activity. It is understood, of course, that the condition of the contralateral lung justifies thoracoplasty. The results from thoracoplasty are usually quite satisfactory. However, there are a number of cases in the literature in which thoracoplasty failed to control recurring hemopthsis in which lobectomy was done with some good results. It has been suggested that in this type of case ligation of the branch of the pulmonary artery to the affected lobe is the procedure of choice.

The type of supportive treatment in pulmonary hemorrhage depends to a large extent upon the degree of the hemorrhage Absolute rest is the most important factor. During the stage of active bleeding, the

patient should be watched continuously. If it becomes evident that considerable blood is being retained in the lungs, prompt and vigorous postural drainage may be life saving. We have seen patients saved by the attendant's hanging the patient's head down over the edge of the bed. In a general way, food and fluid should be restricted for at least twenty-four hours. Soft, easily digested food may be given, avoiding stimulants and hot drinks. The diet should be kept relatively dry for several days thereafter. Attention to the bowels should never be neglected, and it is important that the patient not be allowed to strain at stool for fear of causing a recurrence of bleeding. It has been my practice to wait for twenty-four hours and then give magnesium sulfate in a quantity sufficient to produce easy movement of the bowels.

If the patient has lost considerable blood and signs of shock are present, small transfusions of plasma or whole blood are indicated. This will be necessary only in rare instances.

For after-care or convalescent treatment, the patient should be kept rigidly in bed from a week to ten days after a hemoptysis, during which time he should be thoroughly checked to be sure that there has been no progression of his disease before gradually returning to his previous routine treatment for his disease.

CONCLUSIONS

The most important factors in the emergency treatment of pulmonary hemorrhage are: (1) Rigid bed rest, the position in bed dependent upon the extent and source of bleeding; (2) reassurance of the patient; (3) mild sedation; (4) if the above methods fail, or the hemoptyses recur, collapse therapy should be considered, and of the various methods, pneumothorax is the procedure of choice. This failing, the more radical procedures may be resorted to.

TEMPORARY VERSUS PERMANENT PARALYSIS OF THE DIAPHRAGM IN THE TREATMENT OF TUBERCULOSIS OF THE LUNGS

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IT is perhaps inevitable that a certain aura of mystery should surround the operation of phrenic nerve interruption. In the first place, up to comparatively recent times it was believed that an active diaphragm was essential for the vital function of respiration. Secondly, the causing of the paralysis of a muscle as a therapeutic measure is unique in the realm of surgery. Moreover, this muscle is probably the most active one in the body next to the heart muscle. It has important and diverse functions in the respiratory and circulatory mechanisms as well as providing the dividing barrier between the thorax and the abdomen. Thirdly, the operation as we have come to know it, when well performed, is one of the neatest in its execution and most dramatic and far-reaching in its results in all the surgical repertoire. Through a tiny incision in the neck a small nerve trunk is exposed which on suffering interruption of its axons results in paralysis of half of the great contracting partition of the midtrunk. At the beginning of the present century, Schroeder and Green in animal experiments showed that first one hemidiaphragm and then both sides of the muscle could be put out of action by bilateral phrenicectomy without serious impairment of breathing. Gradually, phrenic interruption came to be recognized as a valuable therapeutic measure in certain diseases of the lungs, notably in pulmonary tuberculosis. Like most newly discovered operative procedures it suffered from overvaluation at first, and at one period it was being performed in almost mass production style in various centers for the treatment of tuberculosis of the lungs. In more recent years the early surge of enthusiasm has died down and with better recognition of the indications resulting from experience gained by observing the many thousands of patients who have now been operated upon, the operation is, or should be, taking its proper place in the general armamentarium of collapse therapy. One says "should be" advisedly because even today there is quite a large amount of divergence of opinion concerning certain aspects of the operation, even among phthisiologists and thoracic surgeons. For the general surgeon who is often called upon to do a phrenic nerve operation, the most important question next to "when should one paralyze the hemidiaphragm in the treatment of pulmonary tuberculosis?" is, "should one cause permanent or temporary paralysis in this or that particular case?" It must be emphasized at once that with very rare exceptions one should always do a temporary paralysis at first. One can never say with certainty beforehand what advantages or disadvantages may accrue as a result of the operation. Should the desired result be obtained, the temporary paralysis can always be easily repeated or the paralysis can be made permanent. If, on the other hand, the operation should fail to influence the disease to the extent required, or if certain disconcerting complications should be the direct result, then no permanent harm will have been done because the diaphragm will once again regain its full function in due course.

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INDICATIONS

The modern concept envisages two distinct views of the operation: (1) The phrenic nerve operation used as an independent therapeutic measure unassociated with other forms of collapse therapy and aided only by the sanatorium régime. (2) The phrenic nerve operation used as (a) a preparatory measure, and (b) an auxiliary measure to some other form of collapse therapy.

INDEPENDENT PHRENIC NERVE OPERATION

As regards this use, John Alexander has pointed out the great guiding principle of the indications. The operation of phrenic interruption used as an independent measure is very effective in early and limited lesions, very ineffective in old and extensive lesions, and notoriously unpredictable in lesions intermediate in type between these two extremes. This is true irrespective of the position of the lesion in the lung field; and those who have had experience with the use of the operation combined with bed rest and sanatorium régime in the treatment of the early lesion, particularly the early uncavitated subclavicular infiltration, are convinced of its great value in this type of case. Most of these patients will do well on bed rest and sanatorium régime alone, but the time required to effect a cure will be shorter and the eventual cure surer in those patients who have had the additional benefit of a diaphragmatic paralysis. In the patient with the early uncavitated lesion or in whom the cavity as seen on the x-ray plate is very minute (1 to 1½ cm. in diameter, for example), there will at first be no question of a permanent paralysis. Six to twelve months' sanatorium régime combined with temporary paralysis repeated once or twice will be sufficient to bring about arrest in most instances. The second or third period of temporary paralysis will usually coincide with the period when the patient will have returned home and resumed his work and normal activities. If in an occasional case at the end of this period after the diaphragm has regained its function there should appear once more signs of reactivation of the disease, it might fairly be judged that a permanently idle diaphragm will be necessary to keep the disease controlled, and a lasting paralysis may be instituted or an artificial pneumothorax may be tried.

In an early lesion which shows signs of cavitation greater in extent than that mentioned above, it is probably wiser to induce pneumothorax in the beginning than to hope for lasting results from phrenic interruption. Experience with pneumothorax therapy has shown that in order to achieve permanent closure of tubercular cavities the collapse must be maintained for a period of at least two and one-half years. Such a term of collapse from diaphragmatic paralysis would necessitate either a permanent interruption or the repeating of the temporary phrenic interruption on three or four occasions. After the operation has been repeated on two occasions, it becomes extremely difficult technically to perform again a fourth time because of the scar tissue that forms and the displacement of the familiar landmarks. Moreover, the injury sustained by the phrenic nerve at each succeeding operation makes return of function less and less likely the more often the operation has been done. In this way one will end up with a permanently paralyzed diaphragm to treat a lesion which could be controlled in all probability more completely and certainly more quickly by an artificial pneumothorax, with much less permanent loss of respiratory function. To those who will point out the objection that pneumothorax treatment is a tedious business which, in addition, lays the patient open to such serious complications as empyema and spontaneous pneumothorax, one may reply that a complete pneumothorax is still the most perfect and efficient form of collapse therapy known to us, and that in the type of case which we are considering, one rarely meets with complications if the pneumothorax is instituted and conducted properly. This argument holds chiefly for lesions

in the upper portion of the lung. When the lesion is in the lower part of the lung, however, one may more readily and with much less misgiving do a permanent paralysis, once the complete effectiveness of the measure has been proved after one or two terms of temporary paralysis. In these cases one loses little in the way of respiratory function because the lower part of the lung is already partially destroyed by the disease, and it will be an advantage to keep it permanently at rest. The function of the healthy upper part of the lung will not be greatly affected by the paralysis of the diaphragm; whereas in treating disease of the upper lobe by permanent paralysis, one loses forever in large part the function of the lower healthy part of the lung.

Apart from the type of case just discussed, the operation is being less and less performed as an independent measure, and according to O'Shaugnessy is being used as such only by those who have a limited repertoire of collapse operations at their disposal. A far more important use of the procedure is first as a preparatory measure, and secondly as an auxiliary measure to some other collapse maneuver.

PREPARATORY PHRENIC NERVE INTERRUPTION

When the operation is intended as a preparatory procedure, the paralysis will invariably be a temporary one. As such, it is used in preparation for (1) artificial pneumothorax and (2) extrapleural thoracoplasty.

1. Kremer strongly advises its use before the attempt at induction of an artificial pneumothorax in cases of fresh, predominantly exudative disease, especially when cavitation lying near the surface of the lung is present. The rest and relaxation resulting from paralysis of the diaphragm will react favorably on these acute lesions causing the exudative reaction to become absorbed and the temperature to become lowered. In this way the pleural exudates rapidly turning to empyemas, and the spontaneous pneumothoraces due to cavity rupture (which are seen unfortunately only

too often when these patients are treated by early pneumothorax) are avoided.

2. The second important use of phrenic nerve interruption as a preparatory measure, as advocated by Hein, is in the case of a lesion extensive enough to warrant a thoracoplasty but which is too unstable to permit the performance of this operation at once. Often in this type of case one is confronted with a small re'ent lesion in the lung of the opposite side which requires some form of active treatment before one dares to contemplate the undertaking of an extensive collapse operation on the more diseased side. A wise plan of campaign in such a case is to induce a protective, so-called mantle, pneumothorax on the less diseased side, and the induction is usually successful in the case of a lung which is the site of such limited disease. Experience has shown that it is desirable to postpone the contemplated thoracoplasty until the contralateral pneumothorax is well established. This will usually take a period of some two to three months to accomplish, and during this time the more diseased side will be made much more suitable for thoracoplasty as the result of the beneficial effect of diaphragmatic paralysis on that side. Seeing that most authorities are now of the opinion that it is safer to have the diaphragm functioning on the operative side during and immediately after the performance of a thoracoplasty so as to avoid lower lobe atelectasis and retention of secretions, one is well advised to cause phrenic interruption by the freezing technic after which the diaphragmatic function is apt to return in the course of two to four months.

AUXILIARY PHRENIC NERVE INTERRUPTION

As an auxiliary measure, phrenic nerve interruption may be used to supplement (1) artificial pneumothorax, (2) extrapleural thoracoplasty and (3) extrapleural pneumonolysis.

1. *Phrenic Nerve Interruption Used as an Auxiliary to Artificial Pneumothorax.* In this connection perhaps its most valuable use is in the case in which artificial pneumothorax has succeeded in partially closing a

cavity or cavities but in which complete closure is prevented by pleural adhesions. The anchoring of the lung to the parietes by

ruption should be a temporary one. Since the artificial pneumothorax should be maintained over a period of at least two
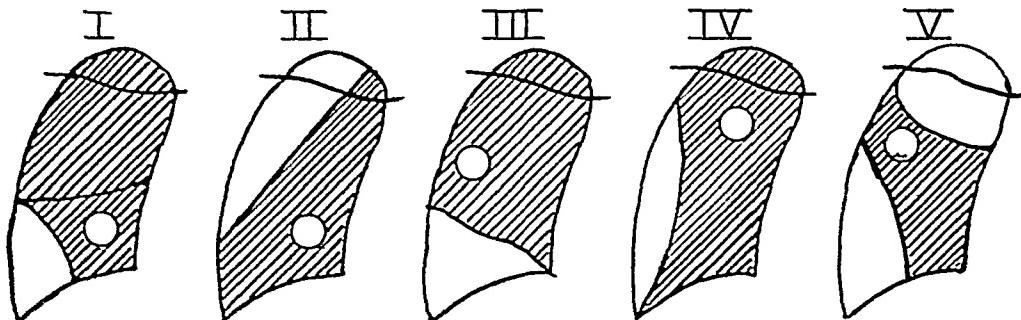

FIG. 1. Diagram showing the types of cases in which favorable and unfavorable results may be anticipated. A favorable result may be expected from phrenic interruption in examples I, II and V. In IV the result is doubtful and in III no success may be anticipated.

adhesions in one direction, together with the intermittent tugging action of the diaphragm in another direction subjects the diseased part to continual irritation and does not permit complete apposition and firm healing of the cavity walls. This may be true even though the actual lumen appears obliterated roentgenologically. Division of the adhesions by the method of Jacobeus is the first and most obvious thing to try. In those cases in which this does not prove feasible, two courses of action present themselves. Either the pneumothorax may be abandoned and a thoracoplasty performed, or paralysis of the diaphragm may be tried. The latter is, of course, much the simpler and less dangerous procedure; and the relaxation of the adhesions which it provides will in many instances permit satisfactory cavity closure and eventual healing. Dumarest has made a particularly interesting study of the results of phrenic nerve interruption as used in conjunction with artificial pneumothorax. His diagrams best show the types of cases in which favorable and unfavorable results may be anticipated. As one would expect, those cases in which the lower lobe has already retracted upward from the diaphragm and those in which the cavity lies in a part of the lung which is adherent to the parietes on all sides present the least favorable prognosis. (Fig. 1.)

These cases are no exception to the almost general rule that the initial inter-

and one-half years after roentgenological and clinical evidence of cavity closure has been reached, and inasumuch as a temporary interruption would have to be repeated on four or more occasions so as to keep the cavity walls constantly apposed and the lung in a more or less fixed position thereby giving it the best chance to heal, it is logical to hold that after the effectiveness of the measure has been proved, one should in these cases go ahead and do a permanent interruption before the diaphragm regains its full function again. In many instances this can and should be done. In cases with bilateral disease, however, and especially in cases in which the contralateral lesion is as yet unstable, one should never rush in to do a permanent paralysis. The contralateral lesion is apt to progress at any time to such an extent that collapse measures may be needed to control it and the permanent reduction in respiratory function resulting from a phrenicectomy may make the performance of the necessary operation extremely hazardous or even impossible. This has been the fate of many patients with bilateral disease on whom permanent phrenic nerve interruptions have been done at an early stage in their disease, and the outcome, of course, has only too often been a fatal one. In such cases one should continue to repeat the temporary paralysis only as often as it seems absolutely necessary and proves feasible; and a seasoned judgment resulting from a long experience

in dealing with the behavior of tubercular lesions is necessary to determine the best course of action in each individual case.

The other important use of phrenic interruption in connection with pneumothorax therapy is in the patient whose disease has been satisfactorily controlled by a pneumothorax which has been maintained over a number of years and which is now being abandoned intentionally or is being lost because of obliterative pleuritis, and in whom such extensive destruction of lung tissue has occurred as to make the eventual full expansion of the lung to fill its original hemithorax hazardous and inconvenient. The hazard arises from the strain to which the quiescent lesion would be subjected under such circumstances, and the inconvenience would derive from the unpleasant subjective phenomena associated with high degrees of negative pressure in the thorax. In extreme instances this inconvenience may grow to real danger when the heart and other mediastinal organs are put under such tension that serious circulatory embarrassment may result. Permanent paralysis of the hemidiaphragm will cause a considerable reduction in the size of the hemithorax, and will help to circumvent the dangers outlined above. Some writers go so far as to advise paralyzing the diaphragm temporarily during the critical re-expansion phase in every pneumothorax, claiming that in this way the frequently observed exudate ex vacuo is not encountered and that the re-expansion is a smoother and less abrupt process. The type of pleural exudate that accompanies re-expansion is, however, usually harmless and it is generally agreed that in most instances phrenic nerve interruption is unnecessary in this group.

2. *Phrenic Nerve Interruption Used as an Auxiliary to Extrapleural Thoracoplasty.* Diaphragmatic paralysis used in conjunction with thoracoplasty has its chief value in those cases showing disease involving practically the whole of the lung in question. The modern thoracoplasty is very effective in controlling upper and midlung disease, but is less efficient in influencing lesions situated in the lower one-third. Such disease processes lying as they do over the broad floor of the thorax, and exposed to the continual disturbing influence of the contracting diaphragm are less subject to the relaxation and compression from above and from the circumference of the thorax, such as is provided by thoracoplasty. Paralysis of the diaphragm which is best done after the completion of the thoracoplasty will give the necessary relaxation from below. Provided the other lung is capable of carrying on the respiratory function adequately, one will desire permanent exclusion of the totally diseased side from activity, and in such a case one may well do a permanent interruption of the phrenic at once.

3. *Phrenic Nerve Interruption Used as an Auxiliary to Extrapleural Pneumonolysis.* Some time after the establishment of an extrapleural pneumothorax or oleothorax it occasionally happens that signs of residual cavitation are detectable just beneath the floor of the artificially created extrapleural space. A temporary paralysis of the diaphragm is always well worth trying in such a case before one decides to resort to thoracoplasty. In this way one subjects the cavity to a collapse effect acting from above and below.

Phrenic nerve interruption is of value in treating certain other aspects of pulmonary tuberculosis in what may be classified as a miscellaneous group:

a. *Hemoptysis.* Some authorities, including John Alexander, are firm in their advocacy of the operation in the treatment of hemoptysis met with in pulmonary tuberculosis. Others discount its value in this instance and hold that it may even be harmful in that it may lead to stagnation of tubercular infected blood in the lung thereby causing atelectasis and dissemination of the tuberculosis. The fact remains that the bleeding does become controlled in many instances after performing the operation. One must be sure from which lung the blood is coming and the respiratory functional capacity must be known to be adequate. Then if an attempt at

induction of pneumothorax has failed, one is justified in doing a temporary paralysis of the diaphragm on the side in question.

b. Spontaneous Pneumothorax. In some instances of spontaneous pneumothorax, the aperture in the visceral pleura is held open by pleural adhesions and in this way the healing of the rent and absorption of the air is prevented. Relaxation of the adhesions and closure of the tear will in occasional cases be made possible by temporarily paralyzing the diaphragm.

c. Tubercular Empyema. In tubercular empyemas that necessitate thoracoplasty to effect closure of the empyema cavity, ascent of the paralyzed diaphragm will occasionally help in obliterating the defect. Provided the respiratory functional capacity warrants it, and seeing that the tubercular empyema cavity is somewhat analogous to a giant pulmonary cavity for which one requires permanent collapse, one may well do permanent interruption in these cases at once.

TECHNIC

The exposure of the phrenic nerve is best done through a transverse incision lying about one finger's breadth above and parallel to the clavicle, its medial end being placed just internal to the lateral border of the clavicular head of the sternocleido mastoid muscle, and extending laterally for a distance of about three inches. The operation can admittedly be done through an incision half this length, but taking into consideration the important and even vital structures that are found in the field and allowing for that cardinal requisite of good surgery—good exposure—one need make no apology for an adequate incision. Skin closure by means of Michel clips, removable in forty-eight to seventy-two hours, leaves a linear scar which becomes well nigh indetectable in the course of time.

Premedication in the form of 1½ gr. of nembutal two hours before the operation, followed by ⅙ gr. of morphine sulfate and ¹⁄₁₀₀ gr. of atropine sulfate one hour before, usually makes the procedure more comfortable for the patient. The best posture is

the supine position with the face turned away from the side of the operation. The skin is prepared according to the wishes of the surgeon and the operative site is adequately draped. Local anesthesia (0.5 per cent novocain) is the anesthesia of choice in the adult, though cyclopropane or nitrous oxide anesthesia may be required for an unco-operative child.

Exposure of the Nerve. The incision is carried down through the skin, superficial fascia and platysma, and superficial layer of the deep cervical fascia, with the scalpel, until one exposes the supraclavicular fat pad. The sternocleido mastoid muscle with the underlying carotid sheath is retracted medially and the external jugular vein is retracted laterally.

The fat pad is divided by repeatedly inserting and opening the tip of a small Metzenbaum scissors and presently one comes down on the prevertebral fascia covering the scaleni muscles. Superficial to this the posterior belly of the omohyoid makes its appearance and as it is usually somewhat sensitive it is injected with a couple of cubic centimeters of novocain and is then retracted upwards. Below the omohyoid the transverse cervical vessels are seen coursing laterally and are carefully avoided.

The phrenic nerve is found lying deep to the prevertebral fascia on the superficial surface of the anterior scalene muscle and gradually edging inward toward the medial border of this muscle as it descends. Lateral to the anterior scalene and emerging from the depression between it and the middle scalene one sees the brachial plexus. Extreme care is exercised in handling the plexus. The phrenic nerve is freed from the prevertebral fascia with a special nerve hook and its identity is proved by lightly pinching it with a hemostat when a convulsive twitching of the patient's epigastrium is caused by the resulting contraction of the hemidiaphragm. One-half to 1 cm. of novocain is then injected into the nerve sheath and the nerve is left for the present. A very careful search is now made for the accessory phrenic nerve or nerves, in the

angle between the brachial plexus and the main phrenic trunk. This is the most usual position for the accessory nerves and the search should be carried up to the point of emergence of the fifth cervical nerve from underneath the lateral border of the anterior scalene and down to the clavicle. It must be stated unequivocably that no phrenic interruption is satisfactorily performed without the finding and resection of any accessory phrenic nerves present. Medial to the main trunk and around the inner border of the scalenus anticus one looks for a possible second phrenic nerve, because cases with double phrenic trunks at this level have been reported. Such a second trunk, if found, must be treated similarly to an accessory phrenic nerve. Finally, seeing that an accessory phrenic nerve occasionally runs in the same sheath as the nerve to the subclavius muscle, this latter nerve which arises from Erbs point of junction of the fifth and sixth cervical nerves and passes down anterior to the third part of the subclavian artery and the subclavian vein is resected in those cases in which it is found. Any strands which appear to be accessories are tested in a similar fashion to the main trunk by pinching with a hemostat and watching for an epigastric twitch.

From now on the course to be pursued depends on whether temporary or permanent paralysis of the hemidiaphragm is desired.

TREATMENT OF THE NERVE

1. *Temporary Interruption: a) Crushing.* The phrenic trunk is crushed three or four times in succession at exactly the same place with a hemostat. Too vigorous a crushing or a crushing involving too extensive a length of the nerve may cause permanent paralysis. Several centimeters of any accessory phrenics found, are resected. This technic will cause a paralysis of approximately six months in duration.

2. *Freezing.* A strip of gauze about 2 cm. in breadth is lifted up under the phrenic trunk. One or 2 cm. of the nerve's

length is then frozen with an ethyl chloride spray or carbon dioxide snow; the accessories or their equivalents are treated as in the crushing technic. Freezing will cause interruption for a period of two to four months.

2. *Permanent Interruption.* Although avulsing the phrenic has been and still is being used widely to cause permanent paralysis of the diaphragm, the radical phrenicectomy as proposed by Goetze and modified by J. Alexander is much the safer operation. In this procedure 2 to 4 cm. of the main phrenic trunk, together with one or more centimeters of all accessory roots, are resected.

In closing, the superficial fascia is brought together with two or three fine sutures of silk or catgut. Approximation of the skin edges is effected with Michel clips and a dry gauze dressing is applied.

COMPLICATIONS OF PHRENIC INTERRUPTION

1. *Immediate Operative Complications:* (a) Severe hemorrhage may occur from injury to a normal or abnormal blood vessel found in the region of the operation, notably from the normal ascending or transverse cervical arteries or from an abnormal branch of the subclavian artery. On the left side the thoracic duct is liable to injury. (b) Pulmonary air embolism is a possibility, due to injury to the internal or external jugular or subclavian veins. This accident while possibly of minor significance in people with healthy lungs is apt to cause serious respiratory insufficiency when the lungs are partially destroyed by disease. (c) Injury to the vagus, sympathetic trunk, or even parts of the brachial plexus has been known to occur.

2. *Remote Complications: a)* Dyspnea is likely to occur in patients with markedly lowered respiratory capacity. One should bear this possibility in mind in particular in elderly patients, over fifty years of age who have a tendency to emphysema, and in patients of any age with extensive destruction of lung tissue. b) Embarrassment of the abdominal organs may occur. The

gastrocardial complex has been observed when unusually high ascent of the diaphragm on the left side interferes with the normal mechanism of the cardia and leads to air swallowing and permanent distention of the stomach. An uncomfortable feeling of fullness and intractable vomiting is the result.

Mechanical ileus has been reported after right-sided operations due to displacement of the duodenum, and constipation as the result of interposition of the large bowel between the liver and the diaphragm. These latter complications are only extremely rarely observed and probably then only in cases with pre-existing abdominal abnormalities such as adhesions or ptoses. When suspicion of such possibilities exists, as for example in cases with peptic ulcer, one should be slow to perform phrenic interruption and one should never undertake an initial permanent interruption.

(c) Undue displacement of the heart and great vessels may result. The healthy cardiovascular system is not likely to be seriously disturbed by paralysis of the hemidiaphragm. Embarrassment may occur, however, in cases with cardiovascular disease, and experiments by Nissen and Wustmann on the caval blood flow are of interest in that they suggest the detrimental effects of permanent diaphragmatic paralysis on the cardiovascular system when the latter begins to be taxed by the common degenerative changes accompanying advancing years.

POSTOPERATIVE TREATMENT

Strict attention to the after-care is one of the most important aspects of phrenic nerve interruption, and one upon which the degree of success or failure of the measure often depends. It is remarkable what a pronounced rise of the diaphragm occurs in patients who are kept strictly on bed rest for long periods after the operation for some such reason as Potts' disease of the spine. If the greatest benefit is to be secured, absolutely strict bed rest should be enforced for at least three months

postoperatively. In addition, the foot of the bed should be raised ten to fifteen inches and the patient should lie as much as possible on the side of operation. In this way, the weight of the abdominal viscera pressing continually upward against the paralyzed diaphragm and the minimal ventilation of the lung resulting from strict bed rest will cause a striking ascent of the diaphragm in those cases in which it is not fixed by adhesions. The position is naturally uncomfortable at first; but if the raising of the foot of the bed is brought about gradually in steps of three to four inches at a time, a co-operative patient will quickly become accustomed to it. The comparatively recent work by Kremer and Von der Weth with the Roentgen-Kymogram shows some promise that by means of this technic one can predict with fair accuracy the amount of success or failure to be expected from a phrenic nerve interruption in treating an upper lobe lesion of more than minimal extent.

SUMMARY

The operation of phrenic nerve interruption is of the nature of a minor procedure in an operative field whose near-vital anatomical structures makes the possibility of serious complications a dangerous trap for the unwary operator. The absolute necessity of strict attention to the indications is borne out by the fact that its well proved efficacy in suitable cases is balanced by its inefficacy and grave dangers in unsuitable cases. The wise surgeon must think twice before he puts half of a patient's diaphragm forever out of action, and the initial paralysis should hardly ever be a permanent one.

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THE RECOGNITION AND MANAGEMENT
OF BRONCHOPLEURAL FISTULA

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A BRONCHOPLEURAL fistula is a communication between the pleural cavity and the bronchial tree, however tortuous the tract may be. It may occur as a complication of a neglected pneumococcic or other pyogenic empyema, as a result of drainage of a lung abscess, or as a result of trauma, but is most commonly found in pulmonary tuberculosis, frequently as a complication of artificial pneumothorax. This paper will concern itself particularly with the problem as encountered in tuberculosis.

The fistula may be of any size, from microscopic to several centimeters in diameter. It may be transient and may be open constantly or intermittently.

The significance of a fistula lies not in the communication itself but in its complications. These fall into three groups, any or all of which may obtain in a given case: (1) Alteration in the intrapleural pressure; (2) infection of the pleural cavity by either or both (a) the tubercle bacillus (from the rupture of a caseous subpleural focus or the sloughing of a cavity wall); (b) pyogenic organisms; and (3) aspiration of pleural exudate into a bronchus. Symptomatically annoying, this frequently causes extensive spread of the disease.

Incidence. To Coryllos and his co-workers[5,6,22] must go the credit for making us realize the high incidence of this condition. Until gas analyses were used, only those fistulas were diagnosed which were large enough to cause abnormal pressure readings or to allow expectoration of appreciable quantities of pleural fluid, either with or without the admixture of a dye such as methylene blue or gentian violet.

In Table 1 is given the incidence of this complication as listed by various authors.

The average is about 5 per cent of artificial pneumothorax cases but represents only those clinically recognized. If we include the small or intermittent leaks which are found only by gas analysis, the figure is much higher. Auerbach and Lipstein[2] give an incidence of 7.8 per cent in 1,000 autopsies of those dying of pulmonary tuberculosis. Of this 7.8 per cent about one-fifth were found in previously uncollapsed lungs. It should be borne in mind that even at autopsy some fistulas, particularly small ones, will escape detection, so the true incidence would probably be in excess of the figures found.

TABLE 1

INCIDENCE OF BRONCHOPLEURAL FISTULA
IN PNEUMOTHORAX

Author	Year	Material	Perforation	Per Cent
Burrell*	..	171 cases pneumothorax	4	2 3
Matson[20]	1935	480 cases pneumothorax	16	3 3
Weisman[29]	1936	130 cases pneumothorax		3 3
		72 cases effusion		7 0
Dumarest and Brette*	..	265 cases pneumothorax	11	4 1
Burnard*		300 cases pneumothorax	14	4 6
Fishberg[12] (Montefiore Hospital)	1932			5 0
Andrew Peters*				5 0
Nicklas, Franklin and Zavod[25]	1937	375 cases pneumothorax	19	5 0
		253 cases effusion		7 5
Forlanini*	..	139 cases pneumothorax	8	5 7
Auerbach and Lipstein[2]	1939	1000 autopsies	78	7 8
Brown and Hayes[16]	1933	230 cases pneumothorax	..	10 0

* Quoted by Fishberg

Bronchopleural fistula is more prone to occur in the early months of pneumothorax, particularly if the collapse is incomplete, but it may occur where a successful pneumothorax has been maintained for a long time. In the series of Brown and Hayes,[16] the average time for occurrence of the fistula in twenty-three cases was the twenty-ninth

month after initiation of pneumothorax. This is probably later than most series would give because in seven of these cases it occurred after the fortieth month and in one after six and one-half years.

Auerbach and Lipstein[2] found at autopsy that those perforations which occurred within six months of pneumothorax were usually associated with a fulminating caseous pneumonia, whereas those fistulas occurring from one to four years later were associated with chronic pulmonary tuberculosis.

Relationship of Empyema to Fistula. If we consider the relationship of empyema to fistula, we find it is a very close one. Alexander[1] states, "It is probable that a majority of all tuberculous empyemas, certainly those secondarily infected, started from a tiny, unrecognized perforation or a larger rupture of the lung." Coryllos,[6] on the basis of his studies of pleural gas analysis, states that bronchial fistula is the most important factor in the pathogenesis of purulent effusion or the change of clear effusion to purulent. However, without gas analysis, this is difficult to prove, although, as Hayes[16] points out, it should be suspected in every case of pleurisy with severe onset even if it cannot be proved at the time.

Without using gas analysis, fistula can be proved in about one-third of all tuberculous empyemas. Skavlem and his co-workers[27] found 20.5 per cent; Woodruff,[30] 30.5 per cent; Nicklas, Franklin and Zavod,[25] 35.1 per cent; Brown and Hayes,[16] 38 per cent; Mainin,[19] 41.3 per cent. Conversely, however, where there is a gross bronchopleural fistula, tuberculous or mixed infection empyema is almost universally found.

Nicklas, Franklin and Zavod's nineteen cases of bronchopleural fistula were discovered among their fifty-four cases of empyema; probably in the majority of instances the empyema was due to the fistula. Auerbach and Lipstein[2] state that in their seventy-eight cases of fistula discovered at autopsy, empyema was present in every instance with the exception of five cases in which the fistulas developed too near death for fluid to develop.

While the majority of large bronchial fistulas are associated with a tuberculous empyema, it is not always easy to prove a secondary pyogenic infection. Many authors have failed to find pyogenic bacteria in a large number of tuberculous fluids in which a fistula is known to be present. It would seem that many of these failures are due to an insufficient number of examinations over a long enough period of time. However, Harpöth and Gad[14] in nine successive cases of fistula over a period of two years failed to find secondary organisms in a single instance. Nicklas and his co-workers[25] found secondaries in only six of nineteen known perforations. In the Saranac Lake series collected by the present author,[30] there were forty-seven cases of fistula and in twelve no secondaries were isolated. However, these twelve included instances in which the patients died quickly after the perforation and other instances in which there were very few bacteriological examinations. In discussing that series Rogers[26] stated that he had had a similar experience—seven negatives in twenty empyemas. Auerbach and Lipstein[2] in their autopsy series found that in forty-four of their cases in which the bacteriology was accurately known, mixed infection was present in twenty-seven, or 60 per cent.

Size and Location. Fistulas range from a microscopic perforation to the actual sloughing of a cavity wall, in which case the fistula may measure several centimeters in diameter. Inasmuch as these fistulas are due to sloughing of tuberculous foci, they are found where the tuberculosis is most extensive and where cavities and adhesions are most likely to be, namely, in the apex of the lung. Auerbach and Lipstein[2] reported 73 per cent in the upper lobe. The minute ones which can be diagnosed only by gas analysis or by variations in intrapleural pressures are the most numerous.

Symptoms. There is no one symptom complex which will cover all cases of fistula. First, it should be borne in mind that, while

the majority of fistulas occur in cases of therapeutic pneumothorax, they can occur in previously uncollapsed lungs. In such a case a fistula initiates the pneumothorax.

Frequently the formation of a fistula is attended by violent constitutional symptoms. In other instances there is no dramatic change and without the aid of gas
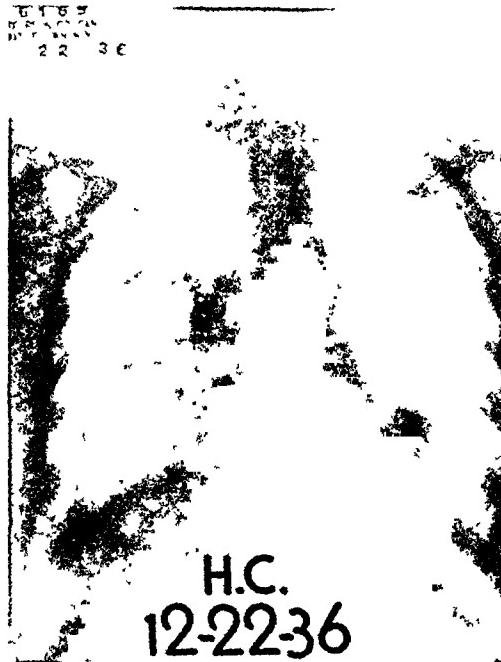

FIG. 1.   FIG. 2.

FIGS. 1 and 2. Case 1. Bilateral pneumothorax before and after development of bronchopleural fistula on the right with tension pneumothorax.
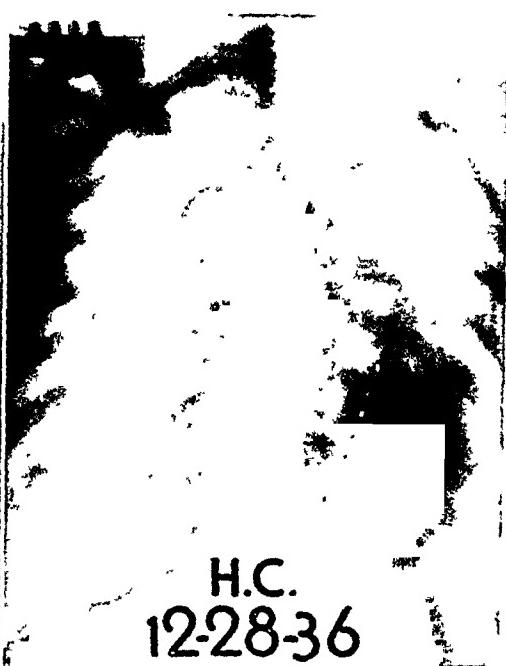
If a fistula is small and temporary, there may be no symptoms and many such cases escape detection.

Dyspnea, if not the most common symptom, is one of the most distressing and one which attracts the attention of both the patient and the physician.

Pain in the chest, sudden fever, unexplained malaise, the expectoration of material either greater in amount or differing in character from that previously raised, are all symptoms, which, when they occur in tuberculosis, should suggest to the clinician the possibility of bronchopleural fistula. Any of these occurring in the presence of an artificial pneumothorax should make him strongly suspect it. In addition, the rapid formation of fluid, particularly if it is cloudy, or the change of fluid already present from clear to cloudy, or a collapse greater in amount than would seem likely from the amount of air injected are all suggestive of the presence of a fistula.

analysis the presence of many fistulas would never be suspected, much less proved.

Diagnosis. In some cases the diagnosis of fistula can be made on the basis of symptoms and signs; in others, the symptoms are merely suggestive and other tests are necessary.

There are two symptom complexes which are easily recognized clinically and which, when present, are pathognomonic: The first is due to a marked change in the intrapleural pressure, with or without signs of infection, and the second is the expectoration of pleural fluid. Both of these are discussed subsequently.

CASE 1. Illustrating the first type of small fistula with developing tension pneumothorax is the case of Mrs. H. C., who was under the care of Dr. S. E. Simpson. (Figs. 1 and 2.)

The author had performed a closed intrapleural pneumonolysis on the right side eleven days before the film of December 22, 1936.

Convalescence was uneventful until the afternoon of the twenty-second when she developed increasing dyspnea, and between the time of the first film and the one of the twenty-eighth, 4,700 cc. of air had been withdrawn from the right side and 800 cc. of air from the left.

CASE II. The second commonly recognized type, in which a patient suddenly expectorates pleural fluid, is illustrated by the Case of Mr. B. S., who was under the care of Dr. J. Woods Price. (Figs. 3 and 4.) Fluid had been forming slowly and on February 6, 1941, 850 cc. were aspirated. During the aspiration fluid was replaced by an equal amount of air. The patient was left with a pressure of +3 + 1, which was quite usual. Following aspiration there was increased elevation of temperature for four days. However, the course was otherwise uneventful until the night of February 14, when he began to cough and raise fluid when recumbent. This fluid was thinner and had a different taste from the sputum which he had previously raised. He soon found that the cough stopped on sitting up or when lying on the left side. This case will be discussed further under "Treatment."

In Cases I and II, and many more like them, the diagnosis is obvious. They repre-

sent the minority of fistulas. Many of the others are more difficult to diagnose and are proved only by other diagnostic

FIG. 3.   FIG. 4.

FIGS. 3 and 4. Case II. Bilateral pulmonary tuberculosis with tuberculous empyema on the left. Figure 3 shows the size of the pocket and Figure 4 shows the position of the catheter. The technic of the insertion of this catheter is illustrated in Figure 9.

methods, at postmortem or not at all. In the autopsy series collected by Auerbach and Lipstein[2] in only 67 per cent was the diagnosis made antemortem.

Whenever fistula is suspected we have a number of criteria and tests at our command. Frequently only one will be positive; in other instances, several. For purposes of discussion we shall list them separately: (1) Physical examination, (2) expectoration of fluid or dyes, (3) pressure changes in pneumothorax space, (4) gas analysis under varying conditions, (5) x-ray or fluoroscopy, and (6) thoracoscopy.

Physical Examination. There is no constant physical finding in all bronchopleural fistulas, although, as Barnwell[3] brings out, "Any respiratory difficulty appearing in a pneumothorax patient should be regarded as due to pulmonary perforation until proved otherwise by a determination of the intrapleural pressure." As he further points out, the symptoms of acute perforation are entirely respiratory until pressure on the

great veins and heart result in circulatory disturbance and until general anoxemia produces convulsions. If the examiner can hear the bubbling of air through fluid or a metallic tinkle, it is probably pathognomonic of a fistula. This is seldom present. If it can be demonstrated that there is a shift of the mediastinum with displacement of the heart away from the suspected side, fistula is strongly suggested. Before it can be considered as absolute proof, one has to be certain that the shift is a new development unrelated to an excessive amount of pneumothorax refill or the development of a large pleural effusion. There may be extreme fullness of the affected side of the hemithorax with bulging of the interspaces. There may be rapid respiration, evidence of air hunger and cyanosis. All of these signs are suggestive; none is pathognomonic. The most important point on physical examination is to recognize dyspnea when present and to realize that increasing dyspnea presents an acute emergency. When it is present, the immediate treatment is directed toward its control. For instance, in Case I air was first withdrawn at 3 A.M. on December 23. Despite the appearance of the film of December 28, no further air was withdrawn because dyspnea was not marked.

Expectoration of Fluid or Dyes. Commonly, a patient who has had fluid in the pleural cavity will begin to expectorate larger amounts or material of a different character than previously. This is characteristically influenced by the patient's posture. In other words, when the orifice is above the fluid level, he will not expectorate fluid; when it is below the fluid level, he probably will. This was true in Case II. Dye placed in the pleural cavity and recognized in the sputum is a great aid when in doubt. Gentian violet when used as an irrigating solution is an excellent indicator. It was used in this instance and seen in the expectoration several days later. Methylene blue is a commonly used indicator, 10 cc. of a 1 per cent solution being used. It tends to fade over a period of days in the

presence of pus. The taste of gomenol is characteristic in those cases who have oleothorax. All of these are proof positive when spat up, but the failure to expectorate them does not mean that there is no communication. In the series of Auerbach and Lipstein,[2] previously referred to, out of thirty-four instances in which fistula was proved at postmortem and in which methylene blue was injected during life, it was expectorated in only twenty-two instances, or in two-thirds of the cases. Nor is the failure to expectorate dye due always to the fact that a fistula is small. It may occur when there is a large opening if the opening is kept above the fluid level. In other instances, if a fistula has been present but is sealed over by fibrin or temporarily closed by pressure, neither fluid nor dye may be spat up immediately.

Aromatic oils, such as wintergreen, have been used as indicators, usually a few drops being placed on a cotton filter in the line of a pneumothorax machine. This is less sensitive than the dye, is open to many errors of interpretation and has little practical value.

Pressure Changes in Pneumothorax Space. These changes may be of two types: (a) Where the fistula is so large and so patent that no matter how much air is injected into the pleural cavity or withdrawn from it, no change in intrapleural pressure can be obtained. In such an instance the diagnosis is clear; but, if there is any doubt, methylene blue placed in the pleural space would probably be expectorated promptly, although it might be necessary to tilt the patient in various positions until one is found in which the perforation would be beneath the fluid level. (b) Where the opening is very small or intermittent, there is a tendency to build up a positive pressure or to fail to maintain a highly negative pressure if one is produced.

This is well illustrated by the following summary of a patient who was under the care of Dr. John Hayes at Sanatorium Gabriels:

Case III, Mr. C. C.   Tuberculous empyema, right side, aspiration and irrigation, with attempt to re-expand, using high negative pressure.

Date	Pressure in Cm. of H₂O		Amount in Cc. Injected or Aspi-rated	Remarks
	Before Treat-ing	After Treat-ing		
6-25-38	−5−0	−23−12	75	Seropurulent material aspi-rated; washed with 550 cc. saline
6-28-38	−6−2	−18−12	350	Air aspirated
7-1-38	−9−12	−24−12	50	Purulent reddish-colored fluid aspirated; washed with 300 cc. saline
7-5-38	−6−2	−15−10	250	Air aspirated
7-8-38	−2+2	−26−16	50	Brownish pus aspirated; washed with 200 cc. saline
7-12-38	+6+8	−24−18	450	Air aspirated; no fluid ob-tainable; washed with 500 cc. saline; added 50 cc. gentian violet, 1:1000
7-15-38	+4+8	−12−2		
7-21-38	−0+4	−4+2	100	Gentian-colored pus aspi-rated; washed with 300 cc. saline; introduction of saline into pleural cavity initiated spasm of cough-ing with raising of gentian violet

It will be noted that on July 8, 1938 the initial pressure was −2 + 2, when three days previously the final pressure was −15 − 10. This reading in itself was quite suggestive of perforation but more marked was the initial reading four days later of +6 + 8. In the absence of a marked increase in fluid, that was presumptive evidence of perforation. It was thirteen days after the first suspicious pressure reading before the diagnosis was verified by the raising of sputum and dye. Dye had been in the pleural cavity for six days before it was expectorated.

The pneumothorax record of Case I is here given in detail as it illustrates an inter-mittently open fistula. It is also an instance of control of symptoms by repeated aspira-tion of large amounts of air.

Case I, Mrs. H. C.   Bilateral pneumothorax. Pneumonolysis, right, 12-9-36 and 12-11-36.

It will be noticed that pneumothorax pres-sures through December 22, 1936 were what might be expected. However, at 3 A.M. on December 23, 1936, because of increasing dyspnea, fluoroscopy was done and revealed almost complete collapse of the right lung.

RECORD OF PNEUMOTHORAX ON RIGHT SIDE

Date	Initial Pressure	Amount of Air in Cc.	Final Pressure	
12-17-36	−6 − 3	Refills 100	−6 − 1	
12-22-36	−11 − 3	250	−7 − 1	
12-23-36	−4 + 4	Aspira-tions 1800	−12 − 3	Spontaneous pneumo-
	−4 + 2	1100	−8 − 2	thorax at 3 A.M. Also
	−5 + 2	1800	−10 − 4	800 cc. removed from left side.
12-31-36	−6 − 2	500	−10 − 2	
1-15-37	−4 − 0	600	−10 − 4	9:00 A.M.
	−12 + 2	800	−14 − 4	7:55 P.M.
1-16-37	? + 16	800	−14 − 4	8:30 A.M.
	−6 + 4	900	−12 − 4	4:55 P.M.
	−6 + 4	900	−16 − 4	7:30 P.M.
	−5 + 3	550	−14 − 12	10:55 P.M.
1-17-37	−8 + 4	900	−12 − 4	1:40 A.M.
	−8 + 3	1100	−16 − 3	8:45 A.M.
	−10 + 3	900	−12 − 4	4:00 P.M.
	−8 + 3	800	−12 − 4	8:00 P.M.
1-18-37	−8 + 2	500	−14 − 4	1:00 A.M.
	−7 + 2	900	−18 − 4	11:30 A.M.
	−6 + 5	700	−16 − 5	2:00 P.M.
	−7 + 3	700	−17 − 4	11:50 P.M.
1-19-37	−7 + 4	900	−16 − 4	9:30 A.M.

Beginning then and continuing for thirty-six hours a total of 4,700 cc. was removed from the right side and 800 cc. from the left. Five hundred cc. more were withdrawn on Decem-ber 31, 1936 and the leak apparently closed. Subsequently on January 15, 1937 it reopened and between then and January 19, 11,950 cc. of air were withdrawn and a needle was left in place. Despite this she died, having been cyanotic for the preceding forty-eight hours.

Case IV developed a fistula that from its beginning was so large that it was impossible to maintain a negative intrapleural pressure.

Case IV, Mr. L. K.   Tuberculous empyema, right side, with unsuccessful attempt to control by oleothorax. Readings include amount of oil given and later withdrawn.

Date	Initial Pressure	Treatment	Final Pressure
11-21-38	−4 + 2	800 cc. cloudy fluid removed − 900 cc. gomenol in olive oil instilled	−4 − 2
1-5-39	−6 − 10	Thoracentesis of 750 cc. oil, 525 cc. cloudy fluid. Air given until pressure was −8 − 3	−8 − 3
1-13-39	+3 + 8	100 cc. air removed Rose to	−8 − 0 −5 + 3 after few minutes
2-7-30	+5 + 0	200 cc. air removed Changed to	−7 + 1 − 3 + 3 when cleared throat

In this case the opening was large enough so that merely clearing the throat or waiting a few moments was enough to alter the pressure materially. In perforations larger than this the administration or withdrawal of large amounts of gas will produce no change in pressure.

In certain instances in which rupture is suspected, a highly negative intrapleural pressure may be produced intentionally to see if there is a leak. Such a method cannot differentiate between a fistula and a leak in the apparatus. Probably it is a safe test provided the pressure is not carried too low. I doubt that any harm follows the use of pressures of -10 to -12 cm. of water. Theoretically, however, a very low negative pressure might result in reopening a fistula which is sealed by fibrin, and it hardly seems justifiable to take the chance of reopening a fistula just to make a diagnosis.

Gas Analysis. The first instance which I have been able to find of the analysis of the pleural gas in a case of bronchopleural fistula is the one described by John Davy before the Royal Society of London in 1823. Because of the historic interest of this case, I am quoting at length from it. The patient also had a spontaneous tension pneumothorax and an empyema.

"Abraham Iredill, of the 7th regiment of Foot, aged 30, was admitted into the General Military Hospital at Fort Pitt, Chatham, on the 15th of January last, labouring under phthisis pulmonalis, and invalided on account of it.

"His disease exhibited some peculiarities, the cause of which was not discovered during life, the chest not having been minutely examined by exposure and percussion, owing to the severity of cold at the time and the hopeless state of the patient, evidently on the brink of the grave. He expired on the 11th of February, and his body was inspected the day following, fourteen hours after death

"The right side of the chest exhibited a great degree of fulness, and it emitted, when struck, a hollow sound. On carefully opening the abdomen, the diaphragm was found protruding into the right hypochondrium, exhibiting a surface convex, and almost conical instead of concave; and it was tense and tympanitic. The right lobe of the liver was pressed into the epigastrium, and rested on a portion of the stomach and duodenum and a part of the transverse colon. Owing to the pressure of the liver, the pyloric portion of the stomach was removed from its natural situation to the left iliac region, where it rested on the upper part of the sigmoid flexure of the colon . . .

"The body was put into a bath, and a small opening was made, under water, with a scalpel, into that part of the right pleura, best adapted by situation to allow the escape of air. Air issued out in abundance: 212 cubic inches were collected in receivers, and about 13 cubic inches escaped, making altogether the enormous volume of 225 cubic inches (almost 3700 cc.).

"On inflating the lungs with a double bellows through an opening into the trachea, the right lung became much expanded, and air was found to pass freely from the lung into the pleura through an ulcerated opening in the upper part of the superior lobe.

"The right lung was carefully dissected out In the upper part of its superior lobe 'a tubercular excavation,' or vomica, was found, of the capacity of about four ounce measures, which communicated with the aspera arteria by a large bronchial tube, the ulcerated end of which terminated in the side of the excavation opposite to the openings by which the vomica communicated with the pleura

"On examining minutely the communication between the cavity of the chest and the lung, a kind of valvular structure was discovered, which would allow of air being pumped into the pleura in the act of inspiration, but not of its escape in expiration, owing to which, no doubt, the accumulation of air in question, took place . . . The cavity opened into the cavity of the chest by a hole in the pleura pulmonalis about the size of a crow-quill, and into the vomica by three smaller holes in the substance of the lung, not corresponding with the former, so that a probe could not be passed from one into the other in a straight line; and, consequently, when the surfaces of the sinus were pressed together by the compression of the air in the pleura in the act of expiration, the communication through which the air entered was closed, and its exit prevented."

The water of replacement from the right pleura when settled showed 1 ounce of white sediment.

"The air collected from the pleura had not the least foetor, nor indeed any smell. It extinguished flame, and was not inflammable. Examined by means of lime-water and phosphorus (which was sublimed in it without effect) 100 parts of it were found to consist of 8 carbonic acid gas and 92 azotic gas.

"It seemed almost demonstrated that the air was atmospheric air altered

"The next question that presented itself was, how the alteration had taken place; what had become of the oxygene that had disappeared; whence the carbonic acid gas with which the azote was mixed?"

The observer clearly described (1) tension pneumothorax and (2) valvular fistula, and he drew the conclusion that the air was atmospheric air altered. When we consider the date, we are also impressed by the accuracy of the gas analysis. To answer his own question regarding the fate of the "oxygene" and the presence of the carbonic acid gas, he carried on a series of experiments with dogs.

Since Dr. Davy's original observation, many other workers have published studies on the composition and changes of air in a pneumothorax space under varying conditions. The reader is particularly referred to the articles by Matsuzawa.[21-24]

When air is injected into the pleural space, there is rapid diffusion through the pleura of all component gases until an equilibrium is reached. If it be atmospheric air which is injected, carbon dioxide will diffuse into the space and oxygen diffuse out. Inasmuch as carbon-dioxide diffuses much more rapidly than oxygen, the volume of a pneumothorax will be temporarily greater shortly after a refill than immediately upon its completion (Dautrebande and Spehl[9]). Carbon dioxide will also reach a stationary level sooner than oxygen, although even in the presence of marked pathology both will have practically reached an equilibrium in twenty-four hours. The rate of diffusion depends upon many factors and, also, the final levels of

the gases vary according to whether the pneumothorax is "dry" or whether there is fluid, and, if fluid, whether or not it is sterile, or contains tubercle bacilli alone or tubercle bacilli plus secondary organisms.

In general, in dry pneumothorax the oxygen level is higher and the carbon-dioxide level lower than when fluid is present.

TABLE II

VALUES OF GASES UNDER VARYING CONDITIONS OF PNEUMOTHORAX WITHOUT FISTULA

	N Per Cent	O₂ Per Cent	CO₂ Per Cent
1. Atmospheric air...	79	21	.03
2. Dry pneumothorax	..		
Birch[5]...............	.	.9 -4.5	5.85-10.0
Coryllos, Konterwitz and Levine[7]........	..	1.0	8.0 -10.0
Coryllos and Welkind[6]	..	3.8	6.0 - 9.0
Harpöth and Gad[14]...	..	2.0 -6.0	4.0 - 8.0
Matsuzawa[21,23].......	..	.88-3.5	5.98- 7.94
3. Fluid	..		
Birch[5]...............	..	.4 -4.31	9.84-14.7
Coryllos, Konterwitz and Levine[7]........	..	... .	14.0 or more
Coryllos and Welkind[6]	..	.0 - .4	10.0 -13.0
Harpöth and Gad[14]. ..	..	.0 -2.0	8.0 -12.0
Matsuzawa[23].........	..	.04-1.5	10.0 -13.0

Also, in the presence of fluid there is a further variation in that the more acute the pleurisy or empyema, the higher the carbon-dioxide level. The table below lists the values given by several different authors for oxygen and carbon-dioxide under varying conditions.

Inspection of the above table reveals that while there are differences, there is fair general agreement.

In dry pneumothorax we have a right to expect an oxygen content of 1 to 5 per cent and a carbon-dioxide content of 6 to 8 per cent. In the presence of fluid, oxygen falls to low levels, rarely being as high as 2 per cent, while carbon-dioxide ranges from 8 to 14 per cent.

With these figures in mind, let us consider the effect of a leak. In the presence of a fistula there will be a tendency for the intrapleural air to approach the composition of alveolar air: N—80 per cent; O₂—15 per cent; CO₂—5 per cent. Any leakage in the thoracic cavity lowers the

carbon-dioxide percentage but increases the oxygen percentage in the imprisoned gas (Harpöth and Gad[14]). The extent of the change will depend upon the size of the fistula and whether or not it is open constantly or intermittently.

By keeping in mind the above factors, it is not too difficult to interpret the findings on single or successive gas analyses.

In a pneumothorax without fluid, any oxygen reading above 5 volume per cent with a carbon-dioxide reading below 6 volume per cent strongly suggests perforation, if the analysis is made at least twenty-four hours following the last refill. In the presence of fluid, an oxygen reading above 2 per cent and a carbon dioxide reading below 10 per cent is of similar import. In each instance, the higher the oxygen and the lower the carbon-dioxide, the more likely it is that a perforation is present and the larger it is apt to be.

Details of technic may be found described by Matsuzawa,[23] Bettman,[4] Birch,[5] Coryllos and Welkind,[8] Harpöth and Gad.[14]

If the fistula is open at the time a sample is taken, the findings by gas analysis are apt to be clear cut. However, if the fistula is very small or if it is temporarily closed, the methods of Bettman[4] and Harpöth and Gad[14] will help. They consist in comparing values for gas content before and after a marked negative pressure is produced. In the absence of fistula the two readings for each gas will be very nearly the same. If there is a fistula through which outside air has entered during the interval, there will be a marked discrepancy in the readings. The dangers of highly negative pressures have been discussed previously.

In many cases where a single analysis is equivocal, serial analyses over a period of several days, even without the use of highly positive or negative pressure, will reveal the presence of the leak.

In this paper a great deal of time has been given to the description of gas analysis as a diagnostic aid in bronchopleural fistula. It has been shown that in many cases the diagnosis can be made in no other

way. However, when it comes to treatment, any case in which the fistula has to be proved by gas analysis might as well be treated as though a fistula did not exist.

X-ray or Fluoroscopy. This type of examination is of value in fistula in revealing: (1) More collapse of the lung than might be expected from pneumothorax refills alone; (2) distortion of the mediastinum away from the collapsed side; (3) depression of the leaf of the diaphragm on the side of the fistula.

All of these findings are relative and while a fistula may be suspected from a single examination, it is difficult to prove on less than two observations, one before and one after the occurrence of the perforation. And these two observations are of maximum value only when we know whether or not the patient has had a refill in between and, if so, how much air was given and what the pressures were. Not infrequently after the administration of an *initial pneumothorax or, less commonly,* after a refill, x-ray or fluoroscopic examination will reveal a collapse of the lung out of all proportion to the amount of air given. In these cases, presumably the pleura has been wounded by the needle and a traumatic pneumothorax has developed. Fortunately, most of these are transient. If the pleura has already been thickened by an inflammatory process or if the intrapleural pressures were nearly neutral or positive, the changes observed following perforation would probably be less marked than if the perforation had occurred while the intrapleural pressures were still relatively negative and before the pleura had become thickened.

Case 1 illustrates a tension pneumothorax. The film of December 22, 1936 revealed bilateral pneumothorax without displacement of the mediastinum, whereas the fluoroscopy of 3 A.M. on December 23, 1936 revealed "almost complete collapse of the right lung."

Observations to be comparable have to be made in the same phase of respiration because, normally in pneumothorax, on

expiration there is a tendency to distort the mediastinum to the opposite side, with its return on the succeeding inspiration.

In attempts to localize the site of a fistula after thoracoplasty, we have injected an opaque medium, such as sodium iodide or iodized oil, into the empyema pocket, turned the patient on his opposite side and taken a film after a few minutes, and have found the opaque medium in the tracheobronchial tree.

Thoracoscopy. In our hands this has been valueless to determine the presence of a fistula. However, in a few instances it has been of value in determining the site of a fistula when its presence is already known. We have had no experience with the treatment of a fistula by thoracoscopy although instances of its successful use appear in the literature.[11,13]

TREATMENT

Treatment consists not in treating the fistula *per se*, but in treating the complications. In many instances, such as puncture of a lung with a needle, no treatment is indicated; also, this is true in other small or intermittent communications. Undoubtedly many of the small fistulas heal spontaneously.

The complications requiring treatment are: (1) tension pneumothorax, (2) drainage of pleural fluid into the bronchial tree, and (3) infection of the pleural space by (a) tubercle bacilli, or (b) pyogenic organisms.

Treatment may be divided into (a) immediate and (b) delayed. Immediate treatment may be needed to control any of the above complications, but once they are controlled, all treatment is concerned with the condition of the underlying lung and pleura, which are the important factors. The lung is frequently heavily infiltrated and almost all constant fistulas are associated with an underlying empyema which will heal only by obliteration of the pleural space. When a fistula is present, the chance of re-expansion is slight. Accordingly, all treatment is based upon the fact that the

patient will probably come to thoracoplasty if his condition warrants, as this is the only form of treatment which adequately controls the pulmonary disease, the empyema and the fistula.

Tension Pneumothorax. This may be described as a condition in which, during ordinary respiration, intrapleural pressures are at all times positive. This is frequently due to a ball-valve fistula which will allow air to pass into the pleura but not out. If a tension pneumothorax develops, the patient and surgeon may be presented with an emergency which, if not relieved, causes death. There is usually time for an x-ray or fluoroscopic examination, although Barnwell[3] records an instance of the patient dying during the trip from the fluoroscopy room. He strongly warns against taking time for x-ray in critical cases. The diagnosis is best made and combined with treatment by taking the intrapleural pressures and withdrawing air until the dyspnea is relieved or until the intrapleural pressure on inspiration is down to minus 10 cc. of water. Sometimes when a physician sees such a patient, he is in extremis. Air should be withdrawn, without delay, by any needle and syringe even if there is no manometer handy. Failure to aspirate promptly has cost many a life. Once the dyspnea is relieved, there is time to plan further treatment. It should be mentioned that frequently the pressures build up quickly again, requiring repeated withdrawals of air. In such an instance, a fairly effective safety valve may be made by taking a No. 18 gauge needle and grinding down the point until blunt. This is then passed through a thin cork. The needle is then inserted into the pneumothorax pocket near its upper point and the cork strapped to the chest. The needle is adjusted so that the point is barely within the pleura. One of two things may be done: (1) A finger from an old surgical glove may be tied over the end of the needle and the end of the finger opened; or (2) a tube may be connected to the needle and led to a sterile flask containing a mild antiseptic.

This flask should be a foot or two below the level of the patient and the end of the tube should be 1 to 2 cm. below the water level.

removed. Within the next few days, and before fluid has had time to reform, drainage should be performed. It is simple and
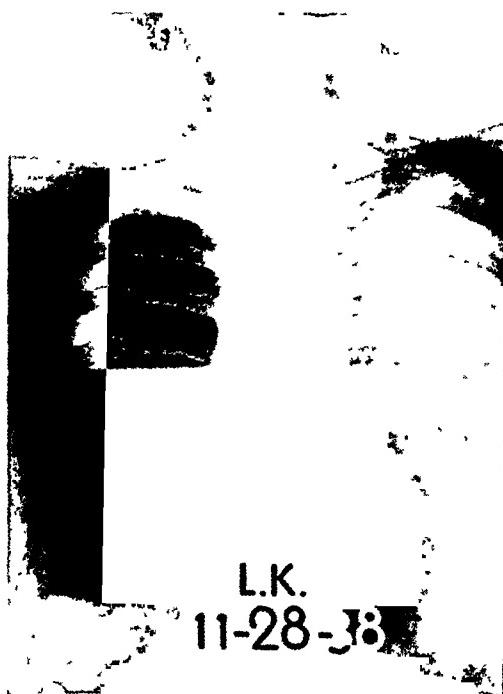

FIG. 5.   FIG. 6.

FIGS. 5 and 6. Case IV. Tuberculous empyema, right. Figure 6 shows the spread of disease in the opposite lung which followed the development of a bronchopleural fistula on the right, with expectoration of fluid.

Either method will prevent the building up of a high positive pressure as long as the needle is not blocked by clotted blood or serum. Care has to be exercised to see that the needle is not blocked and that it does not become loosened and displaced out of the pleural cavity.

Drainage of Pleural Fluid into the Bronchial Tree. Wherever there is purulent pleural fluid draining through a bronchus, there is always the possibility of seeding tubercle bacilli to the same or opposite lung. In addition, even in those cases in which spread does not take place, there is the constant annoyance with disruption of sleep by the continued coughing up of small amounts of pleural fluid. These perforations are usually in the upper portion of the lung and manifest their presence only when the patient lies down and the opening comes below the fluid level. Immediate aspiration should be done and all fluid

usually adequate. It is not safe to depend on repeated aspiration to keep the pleural cavity empty. Case IV illustrates this point.

CASE IV. Mr. L. K., a man of 50, had a pneumothorax on the right induced August 11, 1937. Following two pneumonolyses he developed fluid which became positive for tubercle bacilli eight months later. With the appearance of the fluid the cavity could not be seen and the sputum became temporarily negative. To control the tuberculous empyema, oleothorax was begun in November 1938, and by the twenty-eighth of the month (Fig. 5) fluid and oil had risen to the third rib and fluid formation had apparently ceased. On January 2, 1939, the patient suddenly coughed up a large amount of fluid which contained gomenol. All pus and oil were aspirated *and on January 5 there was no fluid remaining in the cavity.* However, fluid did reform and on January 23, 1939, there was a spread to the left lung. (Fig. 6.) With repeated aspirations the patient developed a pleurocutaneous fistula. Intercostal drainage was

finally performed. Later, rib resection was necessary. He has never since been in shape for thoracoplasty.

ated. When there is no fistula, there is a choice of re-expansion of the lung or of thoracoplasty, depending upon the condi-

C.C.
7-24-38

C.C.
7-17-39

FIG. 7.   FIG. 8.

FIGS. 7 and 8. Case III. Figure 7, tuberculous empyema, right, three days following positive diag-
nosis of perforation but probably more than two weeks after the occurrence of the initial leak.
First-stage thoracoplasty was performed the following day. Figure 8, one year later.

It would seem that if he had had inter-costal drainage when the perforation first occurred, he might never have had the spread to his left lung. Had his perforation been smaller, there would have been less likelihood of his disease spreading.

Infection of the Pleural Space. It has been shown earlier in this paper that in almost every instance of fistula there is a tuberculous infection of the pleura but secondary organisms cannot always be demonstrated. Although tuberculous infec-tions can be very virulent, usually they are less severe than the mixed infection empy-emas and their mortality rate is approxi-mately one-half of the latter. We shall discuss separately the treatment of (a) tuberculous empyema and (b) mixed infec-tion empyema. The discussion will be limited to general principles.

(a) *Tuberculous Empyema.* The author has previously outlined his theories on the treatment of tuberculous empyema.[30] In general, the pleural space must be obliter-

tion of the lung. In the presence of a fistula the possibility of re-expansion is very slight and thoracoplasty should be done as soon as possible. In the majority of instances, drainage is contraindicated unless the fistula is large enough to allow flooding of the bronchial tree, or unless the tuberculous process is extremely virulent. In such in-stances it should be treated as a mixed infection. Early obliteration of the space will frequently forestall mixed infection empyema with its long, trying period of toxemia, and in many instances it will be possible to proceed with thoracoplasty as soon as the fistula manifests itself. When possible, this is ideal treatment. In Case III, previously mentioned, this was possible.

Mr. C. C., age 27, was a patient of Dr. John Hayes, at the Sanatorium Gabriels. Pneumo-thorax on the right was begun February 10, 1938. It was not entirely successful and a phrenic was added on March 26, 1938. The pneumothorax was still ineffective and accord-ingly was discontinued on April 29. During this
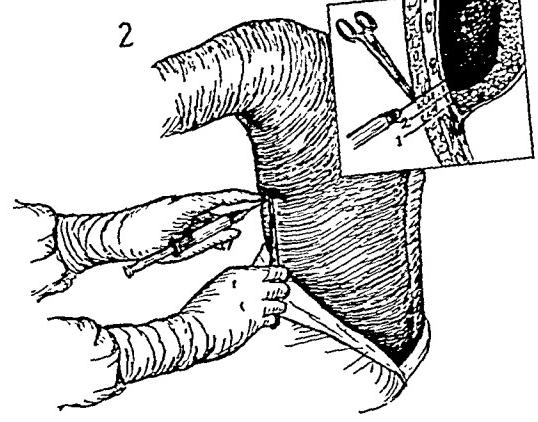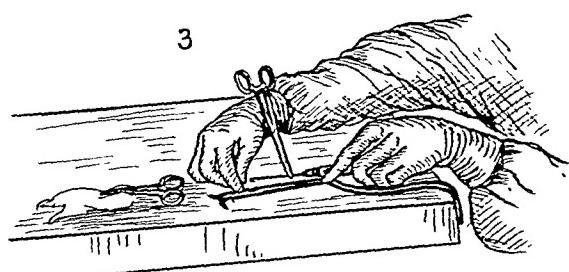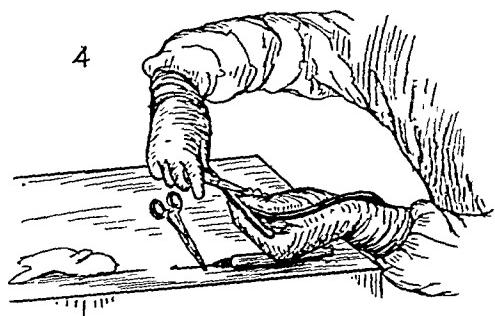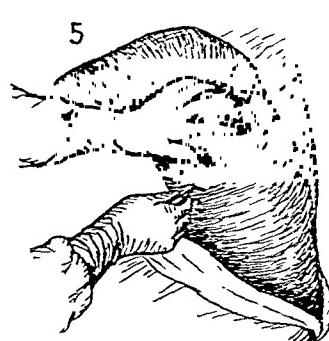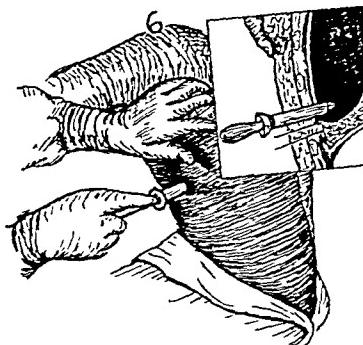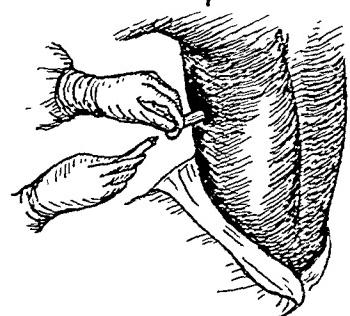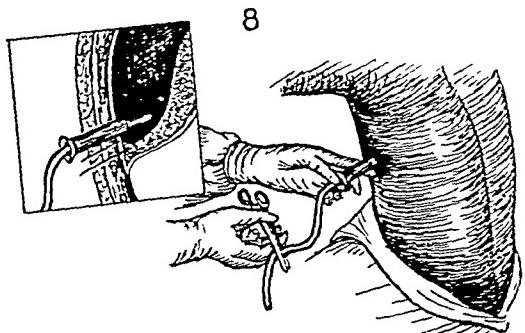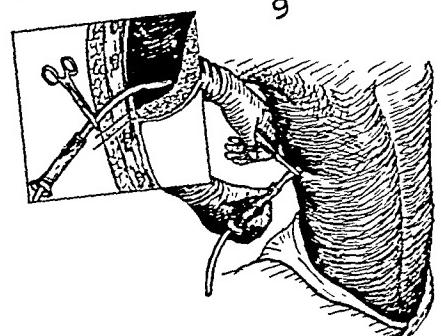
FIG. 9.—For descriptive legend see opposite page.

short pneumothorax, fluid had developed and tubercle bacilli were found. It became frank pus by June, 1938, and re-expansion was attempted

of air. However, three days later the pressure was again positive. Positive diagnosis was not made until July 21 when during the irrigation
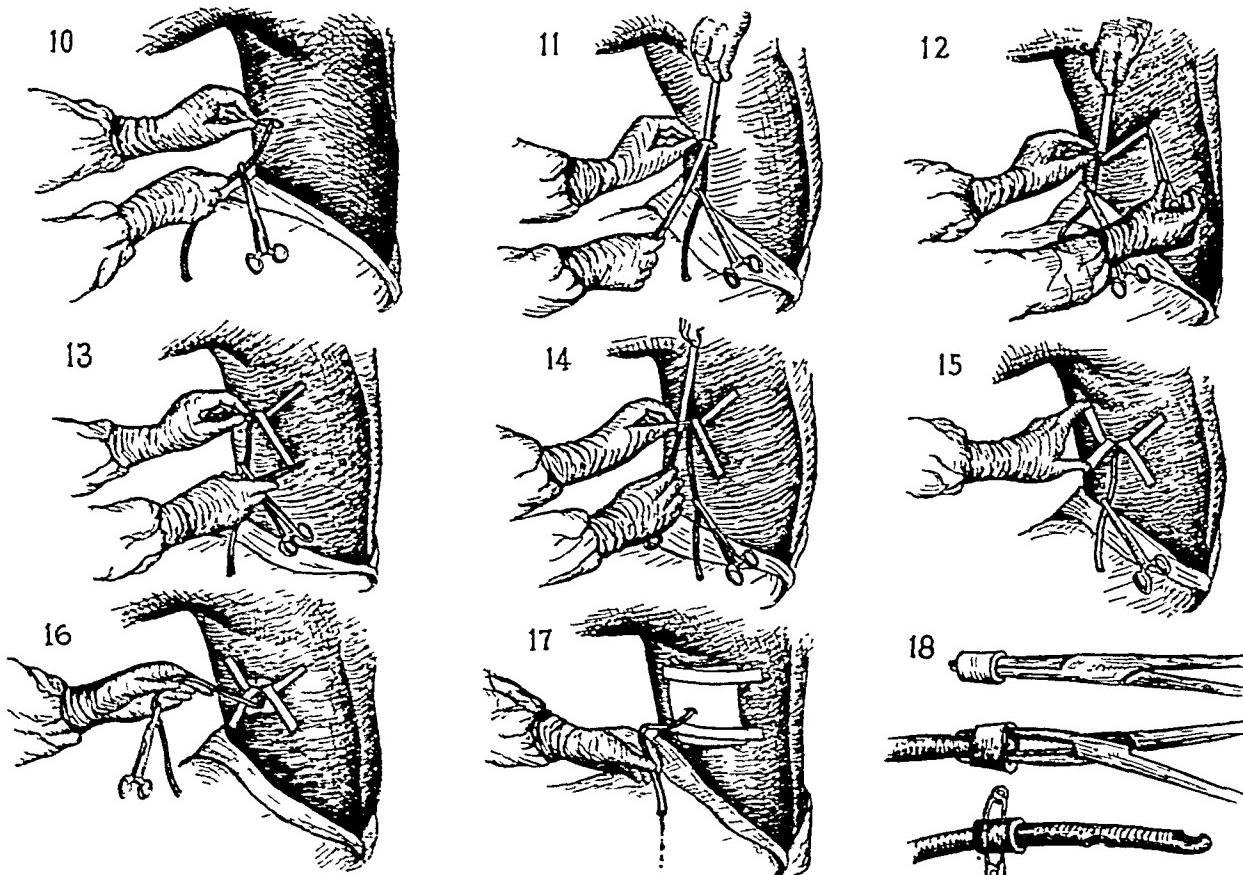

FIG. 9. Technic of introducing intercostal tube. The position of the patient is shown in 1, as well as the site of aspiration. We aspirate from below upward until the pocket is tapped at its lowest point. In 1 and 2 it is seen that there are two dry taps before the pocket is entered. When the pocket is entered, the thickness of the thoracic wall is measured on the aspirating needle by clamping it with the hemostat (2). Several additional eyes are cut in the catheter. From the proximal eye a distance is measured equal to the thickness of the chest wall (3). This point is marked by nicking the wall of the catheter, care being taken not to go into the lumen (4). After the catheter is marked, the trocar is inserted. The skin is held taut with the left hand and the point selected is nicked with the scalpel (5). The trocar and cannula are then introduced (6). The trocar is removed, the gush of pus being controlled by the thumb (7). The previously prepared catheter is inserted for a further distance than is necessary (8). The cannula is withdrawn, the tube being held in place by a hemostat, and the catheter is then withdrawn until the mark previously made in 4 is now at the skin margin (9). A safety pin is passed through the catheter at the site of marking and is fastened to the skin by adhesive straps as described by John Alexander (10–17). It keeps the field cleaner if the tube is kept clamped throughout this stage.

Placing a safety pin directly through a catheter is a disadvantage wherever closed system drainage is necessary, as there is always leakage. Accordingly, when catheters have to be changed, it is simple to insert a catheter with a collar on it. The safety pin is then put through the collar. The method of slipping on the collar is illustrated in 18. A bit of tubing, the same size as the catheter, is taken. The end of the catheter is grasped by a hemostat and the catheter stretched. The collar will then slide easily to any point. It will not slip and the tube will not leak.

preliminary to thoracoplasty. During the re-expansion the patient had pleural lavage. During July a highly negative pressure was obtained, air and fluid being withdrawn to maintain it. The first suggestion of a possible leak occurred on July 12 when the initial pressure was plus 6, plus 8. It was brought to minus 24, minus 18 by the aspiration of 450 cc.

of the pleural cavity the patient started to cough and raised sputum colored with gentian violet. The following day his temperature reached 102°F. Plans were made for immediate thoracoplasty and this was carried out on July 25. Immediately preceding collapse, the pleural cavity was emptied by aspiration anteriorly. (This is quite important because, unless the

pleural cavity is emptied immediately before the patient goes on the table, it is possible to have a spill of a large quantity of infected fluid into the opposite lung.) His convalescence was uneventful. He is now well and working. Figure 7 was taken three days following the positive diagnosis of perforation but probably more than two weeks after the occurrence of the initial leak. Figure 8 shows the patient's condition on July 17, 1939, ten months following completion of his thoracoplasty with obliteration of the pleural space and no evidence of the presence of fistula.

(b) *Mixed Infection Empyema.* The treatment here consists of adequate dependent drainage, supportive treatment and waiting until the patient is in shape for thoracoplasty. In the presence of a fistula, irrigation with various antiseptics has to be used with the greatest caution and is of limited value.

The technic of drainage merits discussion. It is well recognized that in the treatment of empyema the drainage tube should be put into the dependent portion of the chest. However, if it is put in posteriorly, it is uncomfortable for the patient to lie upon. In tuberculous empyema with fistula there is another factor in choosing the site for drainage. That is that thoracoplasty will probably be necessary. Accordingly, it is advantageous to keep the site of drainage away from the site of the thoracoplasty incision so that contamination may be postponed as long as possible. Therefore, the site of election for drainage is slightly in front of the midaxillary line at the lowest possible interspace at which pus can be aspirated. When the drain is introduced in this position, it is possible to empty the pleural space completely by having the patient sit up and lean to the side being drained. With a drain in this position, it is not difficult to keep the thoracoplasty wound uncontaminated through the upper stages.

Drawings (Fig. 9) made from photographs taken during the insertion of a tube in Case 11 illustrate the author's method of procedure in all cases of tuberculous empy-

ema requiring drainage. In many instances this is adequate. In other cases there will be much pain from pressure on the intercostal nerve above. To give relief it is necessary to block the nerve. The author prefers to combine this with the resection of about one and one-half inches of rib at the lowest portion of the pocket in the midaxillary line. Portions of the same intercostal nerve and the one above are taken and the wound closed around the tube. Over a period of time the wound will heal tightly around the tube. When there is no expectation of further treatment and when the patient will continue to drain indefinitely, it is possible to make a larger opening and invert the skin edges. Once such a wound is healed, no tube is needed and the patient can get around with the use of a pad.

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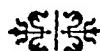
BENIGN LESIONS AT THE LOWER END OF THE ESOPHAGUS

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CARDIOSPASM

ACHALASIA and cardiospasm are two of the most commonly used terms referring to the dilatation and hypertrophy of the esophagus and spasm of the musculature of the cardia. Passage of food normally from the esophagus to the stomach is partially or completely blocked; yet in most instances no true mechanical obstruction can be demonstrated. A few of the many other terms used are phreno-spasm, mega-esophagus, preventriculosis, hiatal esophagismus, simple ectasia of the esophagus and esophagectasia.

Willis described the syndrome in 1674, followed by Hoffmann in 1733. Purton probably reported the first case in 1821 and since then the multiplicity of terms to describe the disease, of hypotheses concerning its cause and of methods to effect its cure well indicate the highly controversial nature of the syndrome.

Etiology. The pathogenesis of the disease is unknown. Many hypotheses have been advanced, but the one suggesting autonomic imbalance seems most acceptable. Cardiospasm in cats can be produced, according to Knight, and Knight and Adamson, by bilateral section of the vagus nerves. The development of the obstruction can be forestalled by immediate removal of the sympathetic fibers and, if obstruction already has occurred, relief may be obtained by sympathectomy. Sympathectomy on human beings, however, as reported by Ochsner and DeBakey, and Skinner and one of us (H. K. G.), has not been satisfactory. Rake demonstrated degenerative changes in the ganglion cells of Auerbach's plexus at the lower end of the esophagus, suggesting an alteration in the neuromuscular control of the sphincter. Ochsner and DeBakey have suggested a chronic deficiency of vitamin B as the cause of this degeneration. Some authorities have based their impression of the causation of cardiospasm on the presence of a cardiac sphincter; yet others have demonstrated as convincingly its absence. Sauerbruch and Haecker, in 1906, suggested that the crura of the diaphragm acted as a vice, constricting the esophagus.

Pathology. There are definite pathologic changes associated with the disease. The esophagus actually may be lengthened, but it is characteristically dilated and its walls are thickened. Lambert described three typical shapes of the esophagus: (1) fusiform, (2) flask-shaped and (3) sigmoid-shaped. Some cases of ulcerative esophagitis at the diaphragmatic level have been noted.

Symptomatology. The characteristic symptoms of the disease are dysphagia, regurgitation and epigastric pain. At least at its inception the majority of the patients are emotionally unstable, with many complaints other than those referable to cardiospasm. Plummer described three stages in its clinical course: (1) cardiospasm without regurgitation of food, (2) cardiospasm with immediate regurgitation of food and (3) cardiospasm with a dilated esophagus and retention of food in the dilated part. It apparently makes little difference if the ingested food be solid or liquid. In the early stages regurgitation is prompt and partial and there is no marked loss of weight. As the tone of the esophagus decreases and dilatation ensues, regurgitation may be delayed for hours and the emesis may be of retention character. The pain is usually

substernal, usually occurs immediately on ingestion and swallowing of food and usually is referred upward to the throat. Dysphagia and pain may occur long before the onset of regurgitation.

Therapy. The treatment of cardiospasm has been reviewed in recent articles by Skinner and one of use (H. K. G.) and Ochsner and DeBakey, among others. The former authors mentioned 1,200 cases of cardiospasm encountered at the Mayo Clinic, with surgical treatment necessary in but seven instances. Moersch, in 1933, reported 810 cases from the same clinic, 805 patients having been treated conservatively by dilatation from above. Seventy-one per cent of the 670 patients traced were well. If the dilatation of the esophagus is sigmoid-shaped as noted by Lambert, surgical treatment may be necessary in order to obtain relief.

Ochsner and DeBakey divided the various types of radical surgical operations into four groups:

1. Operations directed at the dilated esophagus: (a) Excision of the wall, (b) esophagoplication and (c) esophagostomia thoracica. These procedures usually proved to be unsatisfactory.

2. Operations directed at the cardia: Such operations seem more rational. In the cases collected by Ochsner and DeBakey, the results from retrograde and transgastric dilatation are no better than those reported for more conservative treatment. Cardiomyotomy and cardioplasty are two of various plastic procedures on the cardia, and in the collected cases, gave favorable results. Esophagogastrostomy seems the most rational and in the hands of experienced operators gives good results. The transperitoneal route has been found to be preferable to the transpleural route and in most instances should be used. More than 90 per cent of the patients in the collected cases report good results from esophagogastrostomy.

3. Operations directed at the diaphragm: Phrenicotomy and phrenico-exeresis have been done, with uniformly poor results.

4. Operations directed at the nerve supply: These operations were suggested by the assumption of some derangement in the autonomic balance. Vagotomy and sympathectomy seem to be most popular. The results have not been as encouraging as those from esophagogastrostomy. In the collected cases of Ochsner and DeBakey, seven recurrences, three deaths and only one satisfactory result were noted.

EPIPHRENAL DIVERTICULA

Diverticula of the esophagus in various portions of its length are fairly common. They are best classified by their anatomic position and may be divided broadly into three groups: (1) the pharyngo-esophageal, (2) the epibronchial and (3) the epiphrenal or supradiaphragmatic. These may be either true diverticula or false, depending on whether there is protrusion of all coats of the esophagus or merely herniation of the mucous membrane with its submucous coat. Another well known method of classification is that of dividing the diverticula into two types: (1) the traction type, represented by the epibronchial group and occurring at the level of the bifurcation of the trachea; (2) the pulsion type, represented by both the esophagopharyngeal group, located at the hypopharynx, and the epiphrenal group, located at the cardia.

The pulsion supradiaphragmatic diverticula occur in the lower third of the esophagus, usually because of a congenitally weakened esophageal muscular wall. Many authors (Raven) have expressed the opinion that cardiospasm is frequently associated with these diverticula. They occur much less frequently than either of the other types, Granet collecting only forty-nine cases in 1933, and Vinson reporting twenty-four more from the Mayo Clinic in 1934. Scattered reports of epiphrenal diverticula have appeared since, usually included in the larger group of esophageal diverticula, most of which were epibronchial in character.

Ludlow reported "preternatural pockets" in the esophagus in 1764, but the first

reference to epiphrenal diverticula was made by DeGuise in 1833, and roentgenographic diagnosis is mainly responsible for the discovery of most true cases of supradiaphragmatic diverticula.

Etiology. The causation of these diverticula is not known. They are of the pulsion type and the location of the weakness and character of the opening into the sac led Carman to suppose that the majority were congenital. Along with this congenital weakness in the esophageal coat, two further factors may aid in the enlargement of the sacs, once they are formed: (1) the positive intra-esophageal pressure during swallowing and (2) the negative intrathoracic pressure. They usually present on the right side, and this is explained by the anatomy involved (Dessecker). Since the esophagus curves to the left in its lower third to reach the stomach, the impetus of food boluses may be borne by the outer, lower right side of the curve. Once started, the diverticula usually enlarge in a downward direction, toward the right.

Symptomatology. The symptoms are vague and insidious. A feeling of epigastric pressure may precede more pronounced symptoms by months. The cough attending epibronchial diverticula is usually lacking. The actual symptoms depend on the gradual increase in size of the sac. They may be rendered vague by co-existent achalasia. When a large diverticulum is encountered, substernal pain, dysphagia and vomiting of retention are marked. Since the neck of the sac is narrow, the usual complaint is that of vomiting decomposed food, often ingested days before. Often such regurgitation interferes with sleep and is rather characteristic of these sacs. Such putrefaction and stasis cause inflammation of the sac with increased severity of symptoms. Emaciation is usually marked in well advanced cases. Large diverticula may occlude the esophagus by pressure. The diagnosis is rendered usually by roentgenologic examination.

Treatment. The location of the sac usually makes conservative treatment impera-

tive. Often treatment by occasional lavage from above in mild cases is sufficient. Dilation of the esophagus with bougies is attended with success, especially if there is attendant cardiospasm. Extirpation of the sac by surgical means is difficult and imposes considerable risk because of the great probability of soiling the mediastinum or the pleural space or both. In 1933, Lahey first reported a conservative plan of treatment surgically in those cases in which the size of the sac demanded such intervention. He suggested fixing the dome of the freed sac high in the pleural gutter so that it parallels the esophagus with its neck and opening pointing downward. The hazard of pleural contamination and mediastinitis is averted, and food passes readily by the opening unless the patient is in the Trendelenburg position. In four such cases the patients were treated in this manner at the Lahey Clinic. Turner[49] has suggested inverting the diverticulum into the lumen of the esophagus and suturing it in this position. The avoidance of pleural and mediastinal soiling has been accomplished by the method described by Lahey. Subsequent examination is stated to have shown that the sac of the diverticulum that protruded into the esophagus in most instances had undergone atrophy after a short time and was represented by a small structure that was of no anatomic or clinical significance.

ESOPHAGEAL VARICES

Esophageal varices depend for their development both on the obstruction of the portal and lienal veins and on the poor support rendered by the loose connective tissue of the submucosa of the esophagus. The inherent dangers of such varices lie in their tendency to bleed and their inaccessibility for treatment. McIndoe, Preble, Rivers and Wilbur have emphasized the frequency with which fatal hemorrhage attends these varices.

Etiology. The causation of the lesion is not clear, for the conditions most often associated with it, that is, Banti's disease and cirrhosis of the liver, do not present

clear-cut clinical entities. Kegaries and McIndoe have well demonstrated both the anatomy and the physiology of the region. When the portal system has become obstructed, an effort is made to establish collateral circulation and the esophageal veins, because of the connection with the coronary vein and vasa brevia of the cardia, dilate and protrude into the lumen of the esophagus. Varices may be shown to be present in conditions other than the two already mentioned; yet the threat of hemorrhage has been found to be less apparent. Varices of the esophagus may be found in patients who have goiter, following trauma or severe esophagitis. In splenic anemia it is thought that the explanation of the development of varicose veins of the esophagus lies in the connection of the spleen and cardiac portion of the stomach by the vasa brevia.

Diagnosis of the lesion was made much simpler and more accurate by the report of Wolf, in 1928, describing a method of demonstrating the varices roentgenologically. The technic has been steadily improved and perfected as described by Schatzki. Kirklin and Moersch, in 1931, called attention to the value of combining esophagoscopic and roentgenologic examinations to determine the extent of the lesion.

Treatment. Treatment of the varices may be either conservative or surgical. Conservative measures imply protection of the varices from trauma by bland, non-irritating diet, while one attacks the underlying cause. Minimal exercise to avoid strain and sudden increase in blood pressure and avoidance of the use of the stomach catheter are important. Drenckhahn suggested venesection to decrease the viscosity of the blood.

Surgical measures may be directed (1) toward removing or sclerosing the varix, (2) toward reducing as far as possible the amount of blood entering the portal system, (3) toward establishment of new and less dangerous collateral circulation and (4) toward ligation of those routes

already established and contributing to the varices.

The direct removal of the varices is dangerous and unsuccessful. Moersch and others have attempted injection of a sclerosing substance into the varix but this method has not been performed in a sufficient number of cases to warrant definite conclusions being drawn. Moersch is inclined to believe that this method should be performed in conjunction with one of the other methods, preferably splenectomy.

Splenectomy has been performed for Banti's disease for years. It diminishes the total blood volume entering the portal system by about 25 per cent (Drenckhahn) and changes the route of the major portion of the blood that formerly passed through the vasa brevia. Recurrent hemorrhages from splenectomy alone are reported at 50 per cent by Pemberton. Walters, Moersch and McKinnon have reported eighty cases of splenic anemia in which treatment was by splenectomy alone, in all of which bleeding was present preoperatively. In thirty-three of these there was recurrent hemorrhage.

The establishment of collateral circulation may be attempted by omentopexy. The denuded peritoneal surface after splenectomy may offer similar relief. Such methods have not been uniformly successful and have been combined usually with ligation of the coronary vein or even splenectomy.

Ligation of the coronary vein and of the vasa brevia of the cardia in conjunction with splenectomy is a method of interrupting the collateral routes contributing to the varices. Few cases of ligation of the coronary vein alone have been reported and its value as yet is undetermined. Splenectomy combined with such ligation or with omentopexy does not prevent recurrence of bleeding from the varices in more than 38 per cent of the cases (Walters and others).

From a review of the literature it would seem that the most promising treatment,

the value of which is still undetermined, is the injection of the varices by means of the esophagoscope, in conjunction with an attempt to bring the underlying cause under control. The combination of such esophagoscopic treatment with splenectomy seems to offer the best chance of avoiding fatal hemorrhage.

ATRESIA

Congenital atresia of the esophagus occurs rarely, and then often in association with some other anomaly of the gastrointestinal tract incompatible with life. Lanman reported thirty-two cases from the Children's Hospital in Boston in 1940, and stated that he believed the total number of reported cases would not exceed 300. Rosenthal described the embryology fully and Strong and Cummins, Vogt and others have classified the various types of atresia encountered.

The classification suggested by Vogt is excellent if one is to understand and interpret the symptoms and direct attempts at surgical repair. He suggested three types: In type 1 there is complete absence of the esophagus. In type 2 both upper and lower segments end blindly and without tracheal communication. Type 3 he divided into three varieties: type 3 *a*, in which the lower segment is blind, the upper communicating with the trachea; type 3 *b*, in which the upper segment is blind and the lower communicates with the trachea; and type 3 *c*, in which tracheal fistulas are caused by both upper and lower segments. All these varieties are rare, but by far the most common is type 3 *b*.

Symptomatology. The symptoms are characteristic. Attacks of choking and cyanosis are present from birth and are much aggravated by offering milk or water. Depending on the type of anomaly present, regurgitation or choking and coughing predominate. Diagnosis is accomplished by the history and made certain by roentgenographic procedure. Contrast media should not be used because of the danger of aspiration. A small, soft nasal catheter may

be introduced to determine the extent of the upper segment. A small leaden tip may be helpful. Again the type of anomaly will be suggested by the presence or absence of gas in the stomach.

Treatment. The treatment of the condition is necessarily surgical, and the time-honored method is by gastrostomy. This method is only palliative and the patient will not survive if the usually existent fistula is not repaired. As yet there is no uniformly successful method of approach to repair the tracheo-esophageal opening. Richter suggested direct attack on the posterior mediastinum twenty-eight years ago. Extrapleural and transpleural approaches are time consuming and the mortality as yet is very high. The treatment of the upper and lower segments is a controversial subject. Direct anastomosis of the two segments is the ideal method. Lanman expressed the belief that the fistula should first be closed if direct anastomosis is impossible. This is then followed by exteriorization of the upper segment and anterior gastrostomy to prevent aspiration of the overflow secretions and allow feeding. Further construction of an artificial external connection between the esophageal stoma and the gastric stoma can be delayed. Undoubtedly, improvement in technic of approach and exposure, whether transpleural or extrapleural, will brighten the outlook for future success.

BENIGN ULCERS OF THE ESOPHAGUS

Benign discrete ulcers of the esophagus are more common than ordinarily believed. They have a predilection for the lower third of the esophagus and may often be confused with gastric disease. Rivers found that 45 per cent of his patients who had esophageal ulcer gave a history of peptic ulcer. Jackson, by esophagoscopic examination, found in 4,000 cases only twenty-one peptic ulcers, but noted scars of sixty-seven others.

Although Butt and Vinson expressed the opinion that it is merely a phase of acute ulcerative esophagitis, benign ulcer of the

esophagus, exclusive of specific infection, may be classified as traumatic or inflammatory. The traumatic ulcers may be caused by foreign bodies, instrumentation, decubitus, or burns (corrosive). The inflammatory ulcers may be associated with peptic ulcer or with infectious disease.

The ulceration that follows lodgment and pressure by foreign bodies, instrumentation or the swallowing of caustic and corrosive substances can be understood. The cause of simple ulcer with no such traumatic factor is unknown. The inflammatory process surrounding esophageal ulcer is similar to that attending the gastric or duodenal ulcer so often also present.[7] The hypotheses advanced for the causation of acute esophagitis are applicable here. Regurgitation of acid contents of the stomach, heterotopic gastric mucosa, and infection from the buccal cavity are undoubted factors. Often an ulcer attends congenital shortening of the esophagus; often it is a sequel to acute or chronic esophagitis; often it precedes stricture and attends congenital stenosis and hiatal hernia.

Symptomatology. Dysphagia and pain are usually early symptoms, not to be distinguished from those of esophagitis. Pain is usually substernal, made worse by swallowing and referred directly through to the back. Cardiospasm may be present almost with sphincteric action. Esophagitis usually is associated, and may be part of the disease, as suggested by Butt and Vinson. Pain referred to the back may suggest a coincident hiatal hernia or congenitally short esophagus with thoracic stomach. Regurgitation is common but bleeding is less so. The distress may be relieved by alkalis or aggravated by the prone position. Odynophagia is common, and dysphagia may become worse if cicatricial stenosis occurs. Diagnosis is usually made, or confirmed, by esophagoscopic examination.

Treatment. The treatment cannot be specific. The general condition of the patient must be improved and the sources of infection in the mouth and throat removed. A trial of medical management similar to that for peptic ulcer must be instituted. Application directly through the esophagoscope of 10 per cent solution of silver nitrate or chlorlyptus oil has been recommended by Patterson.[33] Often the cardiospasm and stenosis will be benefited by dilatation from above by bougies.

Occasionally, severe and recalcitrant ulceration will require gastrostomy to put the esophagus completely at rest and allow adequate intake of vitamins and calories. Many of these patients approach avitaminotic states because of their prolonged and enforced partial fasting. Adequate quantities of all vitamins should be ensured.

STRICTURE

Stenosis of the esophagus may occur either because of lesions in the esophageal wall or because of extrinsic pressure. This latter type usually occurs in the lower third and has been referred to as compression stenosis. Cardiac enlargement, hiatal hernia, lymphadenopathy and aneurysm are a few factors in the production of the condition. It may be the first sign of the presence of the underlying disease. Dysphagia is the primary and distressing symptom. Diagnosis is usually difficult, but aid can be obtained by roentgenologic examination of the chest and even by esophagoscopic examination. Treatment is that of the underlying lesion, with gastrostomy if necessary to combat starvation.

Etiology. There are many causes of the esophageal stricture due to inflammation or trauma of the esophageal wall. Turner[50] included a description of a specimen of esophageal stricture quoted from Bell's "Surgical Observations" of 1816–1818. Barclay demonstrated that stricture may result from any inflammatory reaction in the esophageal wall. Caustic substances are well known agents; yet both Turner and Vinson[51,56] stated that discrete foreign bodies rarely cause stricture, even if ulceration has occurred. Peptic ulcer of the esophagus, in healing, may exert a cicatricial influence; yet Vinson[58] expressed the

belief that such ulcers cause very little stenosis. Vinson[51] also described nine cases in which esophageal stricture followed the vomiting of pregnancy. Strictures have been reported following the infections of childhood, typhoid fever, diphtheria, severe pneumonia, syphilis and tuberculous ulceration of the esophagus. Congenital shortening of the esophagus, with thoracic stomach, is frequently a cause of ulceration and stricture at the juncture of the esophagus and stomach. Such stenosis is less common than cardiospasm and carcinoma.

There remains a rather large group of cases of esophageal stricture for which no cause can be found. This is known as benign, or idiopathic, stricture of the esophagus. Vinson[53] reported 186 cases of stenosis of the esophagus in 1923, eighteen (9.7 per cent) of which had no known cause. Again in 1931 Vinson[56] reported 243 cases of stenosis of the esophagus and remarked on the increase in the number for which no cause could be demonstrated. Forty of these 243 cases (16.5 per cent) fell in this group. In more than half of the cases this type of stricture occurs in the lower third of the esophagus.

Symptomatology. The symptoms depend on the degree of stenosis encountered. Such symptoms are usually esophageal in origin and character, and the most constant are dysphagia, regurgitation and usually some substernal pain. The history of ingestion of corrosive substances is enlightening. The presence of an inlying nasal catheter or history of intubation is suggestive (Butt and Vinson). Vinson[56] on several occasions has stated that the symptoms usually are absent in those cases of benign stricture of unknown cause. The only significant symptom in this group of cases is dysphagia. Emaciation of starvation and avitaminotic states may occur in cases in which treatment has been neglected for a long time.

The diagnosis of the stricture, even if the cause is unknown, may be made certain by roentgenologic studies and esophagoscopy.

Treatment. The treatment usually be-gins with the conservative methods of dilation and bouginage. Such dilation should always be accomplished with a swallowed thread as a guide. Vinson[58] recently described the procedure minutely and urged that roentgenologic examination of the stomach itself, to detect pyloric stricture, be performed after the swallowing of corrosives. The treatment must be continued over a long period to prevent reformation of the cicatrix. Such therapy is uniformly successful for cases of benign stricture of unknown cause. Complete obliteration of the esophagus from swallowing corrosives is possible and may necessitate gastrostomy to combat starvation and allow retrograde bouginage. Prolonged attempts to pass a thread from above for guidance are urged. Vinson[58] stated that gastrostomy for such pronounced strictures carries a mortality rate of 10 per cent. Turner[50] advised that the opening for the retrograde dilation be made very near the cardia, but he expressed the belief that in the great majority of cases such conditions may be cured by painstaking and patient dilation. He has lately been urging "self-bouginage" over a period of years, for as stated previously, these strictures are always likely to recur.

There are a few cases recorded in which all such conservative methods have failed. After preliminary gastrostomy, plastic operations of the well known Heineke-Mikulicz type have been attempted with varying success. Esophagogastrostomy may be attempted if the lesion is near enough to the cardia. The strictured portion of the esophagus cannot be removed with any degree of success.

One further procedure, anterothoracic esophagoplasty, has been tried in very few recorded cases. Ochsner and Owens reviewed the literature in 1934. Eggers, Garlock and others have been attempting plastic procedures with extrathoracic management of the proximal portion of the esophagus and gastric fistula. The field is very limited in which such procedures may be used; in selected cases (1) of tracheo-esophageal fistula, (2) of benign stricture of

the esophagus impermeable to all known methods of dilation, and (3) of malignant stricture of the esophagus in which carcinoma has been removed successfully.

ESOPHAGITIS

The lower third of the esophagus is exposed to infection both by organisms from the mouth, throat and nasopharynx and by regurgitation of gastric contents. Acute esophagitis is rather common as transient manifestation of the damage done by ingested caustics, alcohol or any trauma. Its occurrence as an agonal feature is shown by Bartels' study of eighty-two cases in 6,000 postmortem specimens. Butt and Vinson found 213 cases of esophagitis in 3,032 necropsies.

Detailed descriptions of the various kinds of esophagitis are easily available. Acute and chronic catarrhal esophagitis; follicular, diphtheritic, phlegmonous esophagitis; and esophagitis due to specific organisms of tuberculosis, syphilis and fungal infections, all are seen but rarely. More common is acute ulcerative esophagitis, the cause of which is uncertain.

Etiology. Butt and Vinson expressed the belief that the trauma of intubation, of vomiting or of the two combined is important. In 46 per cent of their cases an inlying nasal catheter had been associated with vomiting. Bloch reported an even higher percentage; eleven of seventeen patients who had acute esophagitis had been intubated. The frequency of the association of peptic ulcer and acute esophagitis is well known. Penner and Bernheim expressed the belief that most acute esophagitis is an agonal episode, produced by shock. The poor circulation and weak submucous and muscular structure of the esophagus favor embolism and thrombosis and these may play a part in the causation of the condition. The rôle of the nervous system in perforating lesions of the intestinal tract has been emphasized by Cushing. Pneumonia and other serious infectious diseases may have a part. Chronic esophagitis is usually only part of

a syndrome of gastric disease found among persons suffering from chronic alcoholism and among those addicted to the eating of highly seasoned or very hot foods.

Symptomatology. In the series reported by Butt and Vinson 76.5 per cent of the cases were of the acute type, 14.5 per cent were rather subacute, and only 6.5 per cent were of the chronic variety. The symptoms of acute esophagitis may suggest a gastric disturbance. Substernal pain with extension to the throat during and immediately after deglutition, dysphagia and occasional hematemesis are characteristic. Diagnosis in the early stages cannot be proved by roentgenologic examination as a rule, but esophagoscopic examination can be used.

Treatment. The treatment of esophagitis is symptomatic and supportive. In view of the findings of the foregoing authors, the passage of a nasal stomach catheter in the presence of esophagitis would be foolhardy. Sedation, bland foods and parenteral fluids if necessary are helpful. Occasionally, gastrostomy to put the esophagus strictly at rest is necessary.

BENIGN TUMORS

Although benign tumors of the esophagus occur rarely, they must be carefully distinguished from the more common, and usually fatal, malignant varieties. Patterson,[32] in 1932, could collect only sixty-one cases from the literature. Vinson[52,54,55] on several occasions, and Harrington and Moersch more recently, have reported benign tumors of the esophagus seen at the Mayo Clinic.

In 7,459 necropsies these latter authors reported forty-four benign lesions. A great variety of such lesions are reported in the literature. Among the benign tumors found by Harrington and Moersch were cyst, hemangioma, mucocele, neurofibroma, papilloma, polyp, aberrant thyroid, myxofibroma, lipoangioma and adenoma. Recently Harrington has removed a large myxofibroma successfully.

Symptomatology. Symptoms of the presence of such a tumor are most often lacking.

Dysphagia is the most common, however, but even this is usually present only when the tumor mass becomes very large or a pedicle develops. Dyspnea because of tracheal pressure has been reported. Bleeding is very rare.

Diagnosis of the lesion is usually accomplished only at necropsy. The difficulty lies in the fact that so many of the tumors occur in the lower portion of the esophagus and are so often asymptomatic. With the aid of esophagoscopic examination it is possible to detect most lesions once their presence is suspected. This method of examination is not infallible, however, nor is roentgenographic examination, although both are of value in establishing a diagnosis.

Treatment. Treatment of the tumors when found varies with their size and location. It is best to attempt some type of extirpation of the lesion. Harrington and Moersch recommended esophagoscopic removal of the smaller, pedunculated tumors but suggested the surgical removal of tumors involving the muscular layers of the esophagus or tumors in which the attachment is not accessible.

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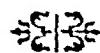
THE PRESENT STATUS OF THE SURGICAL TREATMENT
OF CARCINOMA OF THE THORACIC ESOPHAGUS*

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THERE has been a renewed interest on the part of the surgical profession in recent years in the treatment of cancer of the esophagus. I believe the reason for this is the general dissatisfaction with the hit-and-miss therapy usually accorded this disease throughout the world. Until recently, the diagnosis of carcinoma of the thoracic esophagus carried with it a fatal prognosis and was followed by palliative treatment in the form of deep x-ray therapy with or without a permanent gastrostomy. The final mortality with this treatment was close to 100 per cent. Inasmuch as this was the generally accepted method of handling this disease for many years, a large experience accumulated and it is now possible to scrutinize the effect of x-ray therapy, especially from the standpoint of cure. An enormous literature on the radiation treatment of cancer of the esophagus has accumulated throughout the world. Of the vast number of cases reported, approximately twenty are said to be cured. Careful study of the published results in these cases, in the light of our present day concept of cancer, leaves many of them open to question because, in a considerable percentage, a positive biopsy was not reported, and in the remainder, the follow-up period was too short to warrant the contention that the disease was cured.

Except for an occasional recovery reported since Torek's original successful operation in 1913, the surgical treatment of cancer of the esophagus did not receive the impetus that it deserved until recent developments in the field of anesthesia, and until the physiological changes in the circulatory and respiratory systems accompanying thoracic operations were more clearly understood. With the latter there has been marked progress in the field of thoracic surgery. Surgeons now enter the thoracic cavity with the same sureness as they do when performing a laparotomy. The impetus to attack cancer of the thoracic esophagus by radical surgical means has been strengthened by a gradually increasing knowledge of the subject of cancer in general, and by a clearer understanding of the necessity of radically removing a cancer-bearing focus with all the lymphatic tributaries draining the particular site.

During the past four years, there has appeared, in the American literature especially, an increasing number of articles dealing with the surgical treatment of cancer of the thoracic esophagus. The most recent, that by Adams, published in the February, 1941 issue of *Surgery, Gynecology and Obstetrics*, attempts to summarize all of the cases accorded operative therapy. It is interesting to note that the fourteen patients successfully operated upon before 1934, died within two years after operation, with the exception of Torek's patient, who lived for thirteen years and died at the age of eighty-two of pneumonia. Between 1938 and 1940, thirty-four patients were successfully operated upon, and, of these, twenty or 58 per cent were living and well, some of them up to four years. During this period, about 50 per cent of the sixty-eight reported operations, were successfully consummated. In my opinion, Adams' report does not picture the situation as completely as I believe it to be. I am aware of at least ten other patients who were operated upon by surgeons in New York alone during the period mentioned by Adams, that were not incorporated in his paper. *In*

addition, I know of other successful resections carried out in San Francisco, Washington, Boston and Philadelphia, which were not included in Adams' paper.

From a pathological standpoint, it is important to emphasize that cancer of the esophagus may remain a local disease for a considerable period of time. I would like to stress the fact that the life history of this disease in relation to the findings at operation is vastly different from the usual picture seen in the terminal stages on the autopsy table. Although extension to the regional lymph-nodes may occur late, the tumor itself may become locally inoperable because of fixation to vital structures such as the aorta, bronchus or vertebral column. It must be remembered that the length of history of dysphagia does not picture the extent or size of the tumor. Dysphagia, the outstanding symptom of cancer of the esophagus, does not occur until gross involvement of the esophageal lumen takes place. The tumor may grow outwardly rather than toward the lumen of the organ and may reach an inoperable stage before persistent dysphagia becomes a prominent symptom. A few years ago, I was under the impression that all patients with a short history could probably be classified as operable. But following a rather extensive experience with this disease since then, I have reached the opinion that too great stress should not be placed on the duration of the history in determining operability. I have seen a patient with a history of a year's duration, in whom a radical resection was carried out, and, on the other hand, I have noted three or four other patients with short histories averaging from two to four months, in whom exploration revealed inoperable tumors. In determining operability from the pathological standpoint, it must be emphasized that the location of the tumor is of greater importance. Experience indicates that those tumors located in the middle third of the organ between the arch of the aorta and the left main bronchus quickly become inoperable because of early fixation to one or the other structure.

Tumors located in the superior mediastinum just above the arch of the aorta likewise become inoperable early in the course of the disease because these are prone to involve the left recurrent nerve and seem to spread more quickly to the nodes at the base of the neck. Fixation to the right mediastinal pleura does not, by itself, render the tumor inoperable. On four occasions, I have been able to excise a portion of the right mediastinal pleura with the growth and successfully bring the patients through the operative ordeal in spite of a bilateral pneumothorax on the operating table.

Cancers of the middle third of the esophagus (that portion situated from the upper surface of the aortic arch down to a point about 35 cm. from the upper incisor teeth) metastasize to the mediastinal lymph-nodes, and, late in the disease, to the supraclavicular nodes on the left side. Occasional retrograde metastasis may take place downward below the diaphragm to involve the nodes in the paracardial region and in the gastrohepatic omentum. Cancers located in the distal third of the organ, the most common site (that extending from the lower part of the middle third as far as the cardia of the stomach) usually spread to the regional nodes in the mediastinum. Not infrequently, there is extension below the diaphragm to the paracardial and gastrohepatic nodes. Involvement of the liver is, in my experience, a most unusual route of extension, except in the terminal stages of the disease. Inasmuch as the operation of choice today for cancers of the distal third is a transthoracic, transdiaphragmatic resection with anastomosis between esophagus and stomach, it is always possible to determine lymph-node extension below the diaphragm during the course of the operation. Because lymph-node extension below the diaphragm is most unusual with tumors located in the middle third of the organ, it is rarely necessary to explore the abdomen during the conduct of the operation for removal of tumors in this part of the organ.

It is important to emphasize the implications of the nature of the histological examination of the biopsy specimen obtained by esophagoscopy. The finding of squamous cell characteristics in the tumor indicates origin of the growth from the esophageal mucosa. If adenocarcinoma is found on histological examination, there is definite evidence that the tumor arises from mucosa of the cardia or upper portion of the stomach. I have heard clinicians and pathologists state that adenocarcinoma of the distal esophagus often originates from misplaced gastric mucosa in the esophageal wall. I believe this to be grossly inaccurate. A fairly large operative experience indicates that every instance of adenocarcinoma of the esophagus has demonstrated that the tumor originated in the cardia or upper portion of the stomach.

The lymph-node spread from adenocarcinoma of the cardia is mainly below the diaphragm. In the majority of instances, the extension is in the direction of the paracardial and gastrohepatic nodes. Occasionally, the peripancreatic nodes may become involved. Extension to the portal system with metastatic involvement of the liver may occur early in the disease. In a few instances, I have noted extensive node involvement in the mediastinum above the diaphragm with minimal involvement below the diaphragm. This clear distinction of the difference in lymphatic spread of squamous cell carcinoma and adenocarcinoma is the reason for my suggestion that every case of adenocarcinoma of the lower esophagus should be explored through an abdominal incision in order to determine operability.

Cancer of the esophagus occurs most frequently in the fifth and sixth decades of life. I have seen two patients in the third decade and many in the fourth. The disease apparently is more common in men than in women. There is nothing in any of the histories that I have elicited, which would indicate some predisposing cause, such as chronic irritation. Without exception, every patient has presented the one cardinal symptom of dysphagia, i.e., interference with the normal act of swallowing. Most often, this difficulty is concerned with the swallowing of solid foods and the patient usually states that swallowed food seems to stop at a point in the esophagus which the patient indicates by pointing to a portion of his sternum. Most of the patients have been quite accurate in localizing the site of obstruction, when this was compared with the x-ray films and the findings at operation. Pain on swallowing has not been a prominent symptom in the cases that I have seen. In almost every instance, dysphagia has been progressive, with gradual elimination of solid food from the diet. Most of the patients were able to subsist only on fluids at the time of the first examination.

The extent of loss of weight has been of considerable interest in determining the duration of the disease and arriving at an estimation of operability. My experience to date would seem to indicate that too much reliance should not be placed upon weight loss as an indication of the extent of the disease. The tumor which early impinges upon the lumen will produce a rapid weight loss early in the course of the disease. I have seen one patient who was known to have cancer of the esophagus for one year and yet there had been no weight loss whatever. By the same token, the extent of weight loss has not proved to be of any significance in arriving at an opinion concerning operability.

The symptom of persistent back pain is of serious importance. It usually indicates extension of the growth beyond the wall of the organ with fixation to the aorta or vertebral column. With adenocarcinoma of the cardia, backache may mean pancreatic extension. However, the symptom of backache does not necessarily indicate inoperability because it may be caused by inflammatory reaction in the peri-esophageal tissues.

Every patient with carcinoma of the esophagus should be carefully examined for the presence or absence of an enlarged

supraclavicular lymph-node, the so-called node of Virchow. The finding of a firm supraclavicular node demands biopsy of the node before attempting surgical excision of the esophageal tumor. If node metastasis is demonstrated on histological examination, the case should be classified as inoperable.

It is needless to stress the fact that every patient who complains of persistent dysphagia should be subjected to careful roentgen examination of the esophagus and upper stomach. A negative examination does not exclude the presence of a neoplasm of the organ. If the symptom of dysphagia persists in spite of symptomatic treatment, examination should be repeated after three or four weeks. The finding of an irregularity, a filling defect, or an obstruction, on fluoroscopic and x-ray examinations, calls for esophagoscopy by a competent operator. There seems to be an idea in the medical profession that esophagoscopy is a dangerous procedure. There is little argument with the fact that, in the hands of an inexperienced esophagoscopist, this is quite true. However, with a disease such as the one under discussion, it is important to verify by direct visualization and by biopsy examination, the presence or absence of a carcinoma before attempting radical surgical extirpation. Therefore, the alleged danger of the esophagoscopic examination itself has little significance when compared with the necessity of establishing a positive diagnosis.

Esophagoscopy has a twofold purpose: In the first place, the gross appearance of the tumor is noted and a biopsy specimen is taken to determine the histological characteristics. Secondly, the esophagoscopist notes the distance of the growth from the upper incisor teeth. This, in conjunction with the roentgen film, aids the surgeon in deciding the type of operation he will undertake. As stated before (and it is necessary to emphasize this point), the demonstration of adenocarcinoma in the biopsy specimen calls for preliminary abdominal exploration to determine opera-

bility because of the direction of lymphatic spread that occurs with this tumor. With tumors located in the middle third of the organ, one type of operation is indicated, while, with tumors in the distal third (beyond 35 or 36 cm. from the upper incisor teeth) another operative procedure is carried out.

The decision to undertake radical surgical extirpation of a cancer of the esophagus will rest on a number of factors. The age and general condition of the patient are of considerable importance. It would be poor judgment, in my opinion, to subject a patient in his seventies, with a poor heart, arteriosclerosis and poorly functioning kidneys, to the hazards of so extensive a procedure. On the other hand, I have successfully carried out a one-stage resection in a man of seventy-three years. Each case must be judged on its own merits and it is important to have the help of a competent physician to aid the surgeon in estimating the patient's physical and physiological status. The demonstration of metastatic involvement of the supraclavicular nodes indicates inoperability. Tumors located between the arch of the aorta and the left main bronchus present a special problem. Fixation to either or both structures takes place early and the technical difficulties resulting therefrom may be formidable. The outlook from the standpoint of cure, should the patient survive the operation, is not favorable. None of the four patients in my series has survived a year, and each has died of recurrence in the superior mediastinum. Fortunately, growths in this location are not frequent.

The duration of the history of dysphagia is of some importance in determining operability, but I do not, at the present time, consider it as important as I formerly did. Intralumenal extension of the tumor and the degree of fibrotic constriction of the circumference of the organ are important pathological reasons for the severity of symptoms. These must be carefully appraised.

CHART I

SQUAMOUS CELL CARCINOMA OF THE ESOPHAGUS

Pt.	Male	Female	Age	Approximate Duration of Symptoms	Location of Tumor, Cm.	Biopsy	Operation	Postoperative Complications	Follow-up	Remarks
M. A.		✓	54	8 weeks	36	Squamous cell ca.	9/18/39 resection with intrathoracic esophagogastrostomy.	None.	Alive and well 2 yrs.	Moderate stricture at anastomo. requiring occ. dilatation.
B. B.		✓	48	6 months	30	Squamous cell ca.	4/20/36 gastrostomy. 4/29/36 Torek.	Left empyema, Pellegra, recurrence in esoph. stump 6 mo. later.	Died of recurrence in superior mediastinum 22 mo. later. Died four mo. later of disease.	First case of series.
S. B.	✓		50	3 months	26	Squamous cell ca.	9/1/39 Janeway gastrostomy. Tumor inop.	None.	Alive and well 2½ yrs.	No evidence of stricture.
J. C.	✓		60	5 weeks	39	Squamous cell ca.	4/27/39 resection with intrathoracic esophagogastrostomy.	Right pleural effusion 1200 cc.	Died of mediastinal recurrence 11 mo. later.	Part of rt. mediastinal pleura excised at op.
P. C.		✓	54	3 months	31	Squamous cell ca.	2/20/40 Witzel gastrostomy. 2/28/40 Torek.	Localized left empyema.	Died of disease 2 mo. later.	
F. C.		✓	65	4 months	25	Squamous cell ca.	-/28/36 Janeway gastrostomy. 8/27/36 Explor. inop. supra-aortic.	Lobar pneumonia.	Died on 6th postoperative day of pneum.	
A. G.	✓		62	5 weeks hoarseness 3 days	24	Squamous cell ca.	5/26/38 Janeway gastrostomy. 6/13/38 Explor. inop. supra-aortic.	Fulminating pneumonia.	Died 1 year later of mediastinal recurrence.	
M. G.	✓		35	8 weeks	30	Squamous cell ca.	8/21/39 Janeway gastrostomy. 8/31/39 Torek. Tumor bet. bronchus and aorta.	R.L.L. pneumonia, encapsulated left empyema.	Died 2nd day postop.	
M. McC.	✓		61	3 months	32	Squamous cell ca.	9/16/39 Janeway gastrostomy. 9/30/39 Torek.	Cerebral hemorrhage. None.	Alive and well 5 yrs.	Second case of series.
H. M.		✓	53	8 weeks	34	Squamous cell ca.	11/16/36 Janeway gastrostomy. 11/28/36 Torek. 6/24/37 Antethoracic esoph.	None.	Died 2nd day postoperative.	Death due to error of judgement.
E. P.		✓	56	10 weeks	34	Squamous cell ca.	3/14/39 Janeway gastrostomy. 3/22/39 Torek. Piece of rt. mediastinal pleura excised.	Tension pneumothorax, right.	Died 2nd day postop.	Exceedingly difficult technical procedure.
F. S.	✓		49	3 weeks	34	Squamous cell ca.	10/26/39 Resection with intrathoracic esophagogastrostomy.	Surgical shock.	Died first day postop. Intensive radiation therapy postop.	Died one yr later of mediastinal recurrence.
J. S.	✓		4-	- months	30	Squamous cell ca.	10/10/38 Janeway gastrostomy 10/20/38 Torek. Tumor bet. bronchus and aortic arch.	None. Unexplained tem. to 106 on second day.	Died 3 mo. later of coronary disease.	Autopsy showed cav. in mediast. No cancer tissue.
J. T.	✓		48	5 weeks	35	Squamous cell ca.	9/13/37 Janeway gastrostomy. 9/20/37 Torek.			

CHART I (Continued)

Pt.	Male	Female	Age	Approximate Duration of Symptoms	Location of Tumor, Cm.	Biopsy	Operation	Postoperative Complications	Follow-up	Remarks
G. B.	..	√	43	3 months	26	Squamous cell ca.	7/14/41 thoracic exploration. Tumor inoperable. Stamm gastrostomy.	None.	Still alive.	
S. F.	√	..	59	4 weeks	39	Squamous cell ca.	5/8/40 resection with intrathoracic esophagogastrostomy.	Postoperative pneumonia of both lungs.	Died 3rd day postop.	Autopsy showed involvement of peripancreatic and coeliac nodes.
J. K.	√	..	53	2 months	30	Squamous cell ca.	4/3/40 Spivack gastrostomy. 4/17/40 Exploration. Inop. tumor.	None.	Died four mo later of disease.	
R. F.	.	√	43	4 months	30	Squamous cell ca.	-/29/40 modified Torek preserving distal 2 inches of organ.	Unexplained convulsion on third day.	Alive and well 1 yr.	
H. K.	√	.	66	10 weeks	29	Squamous cell ca.	-/1/40 Janeway gastrostomy. 7/24/40 Exploration. Inop tumor attached to aorta.	None.	Died four mo later of disease.	
R. L.	√	..	6-	4 months	33	Squamous cell ca.	5/11/40 Spivack gastrostomy. 5/29/40 Torek.	R.L.L. Bronchopneumonia. Pulmonary edema.	Died 48 hrs postoperative.	
B. A.		√	57	1 year	29	Squamous cell ca.	11/23/40 modified Torek.	Cerebral embolus. Left empyema.	Died 11th postop. day	Long hist. no wt. loss. Resectable tumor.
W. B.	√		72	10 weeks	36	Squamous cell ca.	1/8/41 resection with intrathoracic esophagogastrostomy.	Small right pleural effusion.	Alive and well 8 mos. postoperative No stricture.	Part of rt. mediastinal pleura excised. Age of pt. noteworthy.
S. G.	√		52	4 weeks	30	Squamous cell ca.	3/20/41 modified Torek	Developed fulminating pneum.	Died on 9th postop. day	Operative risk not good.
W. M.	√	.	54	- weeks	33	Squamous cell ca.	4/30/41 resection with intrathoracic esophagogastrostomy.	None.	Alive and well 5 mos.	There was also an early adenoea. of stomach near cardia. This was also excised.
Newark case.	√		53	5 months	30	Squamous cell ca.	4/10/39 Janeway gastrostomy. 4/19/39 Exploration—inoperable.	None.	Died 3 mos later of disease.	
M. G.	√	..	64	3 months	20	Squamous cell ca.	4/19/41 cervical exploration. Inoperable. 6/2/41 gastrostomy.	None.	Still alive	Left recurrent nerve paralysis
G. R.	√		49	6 months	29½	Squamous cell ca.	12/18/40 modified Torek op.	Acute coronary occlusion with infarction of myocardium	Died 3d day postoperative.	Cardiac death
S. S.	.	√	56	3 months	29	Squamous cell ca.	9/7/40 thoracic exploration. Inoperable. Witzel gastrostomy.	None.	Died 3 months later.	Tumor adherent to aorta and pericardium.
P. K.	√	.	58	3 months	3-	Squamous cell ca.	11/2-/40 abdominal exploration. Inoperable. Gastrostomy.	None.	Died 4 mos. later of disease.	Tumor adherent to aorta and vertebral col
J. K.		√	42	6 months	33	Squamous cell ca.	11/2-/40 thoracic exploration. Inoperable. Stamm gastrostomy.	None.	Died 3 mos. later of disease.	Tumor adherent to thoracic aorta.

CHART II
ADENOCARCINOMA OF THE CARDIA

Pt	Male	Female	Age	Approximate Duration of Symptoms	Location of Tumor, Cm	Biopsy	Operation	Postoperative Complications	Follow-up	Remarks
H Z	x		62	5 months	40	Adenocarcinoma	10/13/39 abdominal exploration Inop	None	Died of disease 4 mos later	
I S	x		36	6 months	39	Adenocarcinoma	10/10/38 thoracic exploration Inoperable Gastrostomy	Fulminating pneumonia	Died on 3d day postop	At present time would explore abdomen first to determine operability
M M	x		60	4 weeks	40	Adenocarcinoma	10/6/39 transthoracic exploration Inop Gastrostomy	None	Died 5 mos later	At present time would explore abdomen first to determine operability
S R		x	58	6 weeks	38	Adenocarcinoma	5/21/40 abdominal exploration Transthoracic resection with anastomosis	None	Well 16 mos postoperative	One lymphnode showed involvement
A M	x		60	about 9 months	40	Adenocarcinoma	6/6/40 abdominal exploration Transthoracic resection with anastomosis	None	Well 15 mos postoperative	No involved nodes found
C I		x	60	2 months	39	Adenocarcinoma	3/-/40 abdominal exploration Inoperable Spivack gastrostomy	None	Died of disease 3 mos later	
H S	x		6-	2 months	40	Adenocarcinoma	6/28/40 abdominal exploration Inoperable	None	Died 4 mos later of disease	
S I	x		48	10 weeks	35	Adenocarcinoma	12/28/40 abdominal exploration Inoperable	None	Died 5 mos later of disease	
G K		x	55	6 months	38	Adenocarcinoma	10/25/40 abdominal exploration Inoperable Janeway gastrost	None	Died 3½ mos later of disease	
I G		x	52	8 weeks	39	Adenocarcinoma	6/28/40 abdominal exploration Inoperable Janeway gastrostomy	None	Died 6 mos later of disease	
J G	x		36	6 months	40	Mucus cell carcinoma	3/10/41 abdominal exploration Transthoracic resection and anastomosis	None	Well 6 mos postoperative	Associated lymph-nodes removed with tumor showed involvement
H C	x		66	1 year	40	Adenocarcinoma	4/1/41 abdominal exploration Transthoracic resection with anastomosis	Coronary occlusion on 6th day	Died suddenly on 6th day	Length of history and operability noteworthy
I L	x		51	4 weeks	40	Adenocarcinoma	5/5/41 abdominal exploration Inoperable	None	Still alive	

CHART II (Continued)

Pt.	Male	Fe-male	Age	Approxi-mate Duration of Symp-toms	Location of Tumor, Cm.	Biopsy	Operation	Postoperative Complications	Follow-up	Remarks
J. A.	√	..	49	3 months	39	Adenocar-cinoma.	1/26/39 trans-thoracic resec-tion and anas-tomosis.	Cerebral em-bolus.	Died on 3d day.	Lymph-nodes showed in-volvement.
M. B.	..	√	70	8 months	39	Adenocar-cinoma.	1/29/38 abdomi-nal exploration. Inoperable. Janeway gast.	None.	Died of dis-ease 2 mos. later.	
J. B.	√	..	62	4 months	40	Adenocar-cinoma.	10/5/39 abdomi-nal exploration. Inop. Janeway gast.	None.	Died of dis-ease 3 mos. later.	
W. C.	√	..	47	3½ months	39	Adenocar-cinoma.	10/25/39 ab-dominal explo-ration. Chest exploration. Inoperable.	None.	Died of dis-ease 4 mos. later.	Extensive me-diastinal node involvement.
C. D.	√	..	56	5 months	36	Adenocar-cinoma.	2/1/38 Janeway gastrostomy. 4/19/38 chest exploration. In-operable.	Postoperative pneumonia.	Died one mo. later.	
L. E.	..	√	73	10 weeks	39	Adenocar-cinoma.	8/3/39 trans-thoracic resec-tion and anas-tomosis.	Became coma-tose on 3d day.	Died on 4th day.	Autopsy essen-tially nega-tive.
W. H.	√	..	49	6 weeks	40	Adenocar-cinoma.	6/20/39 trans-thoracic resec-tion and anas-tomosis. 7/2/39 right thoracotomy for pyopneu-mothorax.	Developed lung abscess, rup-tured of rt. lung.	Lived for 16 mos. Died of extensive re-troperitoneal metastases.	Resected speci-men showed extensive node involvement.
H. H.	√	..	30	6 weeks	40	Hodgkin's disease of cardia.	4/12/41 abdomi-nal exploration. Transthoracic resection· and anastomosis.	None.	Doing well 5 months post-operative.	This case is in-cluded in series for obvious reasons.
M. F.	√	..	61	5 months	40	Negative biopsy.	5/14/41 explor-atory laparot-omy. Inop.	Several severe gastric hem-orrhages.	Still alive.	
M. B.	√	..	57	3 months	40	Adenocar-cinoma of cardia and lower esoph-agus.	5/21/41 explor-atory laparot-omy. Trans-thoracic resec-tion and esoph-agogast.	Mediastinal ab-scess and per-itonitis.	Died on 9th day postoper-ative.	Leakage from small perfora-tion of esoph. at site of oper-ative injury. Suture line in-tact.
H. G.	√	..	57	3 months	40	Adenocar-cinoma.	6/4/41 abdomi-nal exploration. Inop.	None.	Still alive.	

Once the decision to undertake surgical treatment is made, the patient's general condition and his physical reserve after thorough preoperative preparation must be carefully appraised. It is important to pay special attention to oral hygiene. Carious teeth should be extracted and infected gums should be cleansed. This will natu-rally decrease the possibility of post-operative pulmonary complications. Great weight loss may be due primarily to ex-treme dehydration. The daily intravenous

injection of 1,000 to 2,000 cc. of 5 per cent glucose in saline over a week's period often results in astonishing improvement of the patient. In a recent case, the patient gained ten pounds in seven days. Unless complete obstruction is present, the patient should be encouraged to take large quantities of high-caloric liquids containing the necessary vitamins and minerals. In many instances, parenteral administration of vitamins will be necessary. It will be found that taking one or two weeks to improve the patient's general condition is time very well spent.

The question of preliminary gastrostomy deserves special mention. Till recently, I was of the opinion that most patients required a preliminary gastrostomy to aid in restoring fluids, proteins, etc. At the present time, I have the opposite viewpoint and believe that, except for the rare exception, most patients can be gotten into satisfactory condition by the methods above enumerated. To aid in restoring lost proteins, I have, in the last few patients, given amino acids intravenously, after the method of Elman. I believe this will prove to be of inestimable value in the preoperative preparatory period. The presence of a gastrostomy would seriously interfere with the carrying out of the operative procedure I recently described for carcinoma of the middle third of the organ and with the operation of resection and esophagogastrostomy for tumors of the distal third. Should alimentary feeding be necessary, jejunostomy instead of gastrostomy should be performed, and the operative incision should be placed at or below the umbilical line.

In most instances, it will be necessary to administer a blood transfusion before operation. A transfusion *during* operation is, in my opinion, obligatory. A third transfusion during the early period of convalescence is also most desirable. In order to decrease the number and virulence of the organisms covering the ulcerated surface of these neoplasms, I have routinely administered one of the sulfonamide drugs (usually sulfanilamide) for seventy-two hours prior to operation, in 15 gr. doses every four hours. An additional line of attack against the bacterial flora of the ulcerated neoplasm has consisted of mechanical cleansing by frequent irrigation with warm saline solution through a Levin tube.

A few writers have emphasized the need of pneumothorax prior to operation in order to accustom the lung to the positive intrapleural pressure which occurs during the operation. I have never seen the need for this, relying on the anesthetist to maintain varying degrees of positive intrapulmonary pressure. I do not subscribe to the recommendation of a few authors that the phrenic nerve be crushed either prior to or during the operation. Paralysis of the diaphragm adds another burden to an already handicapped patient in his effort to obtain maximum pulmonary ventilation.

In my experience, the combination of avertin and cyclopropane or ethylene has been most satisfactory. Complete collapse of the lung should not be permitted to take place at any time and the anesthetist should have complete control of the situation. It is important to secure the services of a competent anesthetist because the incidence of postoperative pulmonary complications depends in large measure on the skill of administration of the anesthetic agent.

A few writers recommend intratracheal anesthesia, stating that the degree of inflation of the lungs can be more accurately controlled by this method. I have believed that the trauma of intubating the trachea in these debilitated patients may well be a factor in the development of pulmonary complications and have, therefore, had no experience with this method.

The ideal to be sought after in the surgical treatment of cancer of the thoracic esophagus is radical resection of the cancer-bearing portion with all the associated lymph-nodes and re-establishment of esophagogastric continuity. With tumors located in the middle third of the organ, it has been impossible, up to the present time,

to attain this ideal to its fullest extent because, with the operative procedures so far evolved, it has been impossible to re-establish continuity following a radical resection. Although the Torek operation has stood the test of time and experience and although I have modified it to the extent of eliminating a preliminary gastros-tomy and of preserving the sphincteric action of the cardia, I have always believed it was a makeshift procedure, leaving the patient with an artificial esophagus which was far from desirable from all standpoints. Because of this, I am trying to develop a new operation which will eliminate these objections. I am not prepared to say what the final result will be but the procedure seems to have some merit.

With tumors located in the distal third of the organ or in the cardiac end of the stomach, the operation of choice is a left transthoracic transdiaphragmatic resection of the lower esophagus and upper stomach, mobilization of the proximal two-thirds of the stomach and a suture anastomosis between the end of the severed esophagus and the upper anterior wall of the stomach. In previous papers, I have described in great detail, the technical steps of this operation and also, of the modified Torek procedure for cancers of the middle third. That the operation of esophagogastrostomy is physiologically and anatomically sound is proved by the fact that there has not been a single instance of leakage from the suture line in the entire series of cases reported herewith. In a recent case, post-mortem examination disclosed leakage from a perforation of the esophagus one-half inch above the suture line due to operative injury of the organ at this site, a preventable technical error.

It must be emphasized that the operation for cancers of the middle third carries with it a greater postoperative morbidity and a higher mortality than the operation of esophagogastrostomy for tumors of the distal third. Greater operative trauma in-volving the entire mediastinum instead of only the distal portion, handling of the arch

of the aorta in freeing the esophagus from its posterior surface and the possibility of increasing the already existing pneumo-thorax during the cervical phase of the operation are major reasons for the in-creased morbidity and mortality. In spite of the fact that the Torek operation is an excellent one from the standpoint of free exposure and good cancer surgery, the above enumerated objections have made for dissatisfaction and a desire to provide a method which would approach the ideal already expressed.

My own experience to date consists of the operative treatment of fifty-four can-cers of the esophagus and cardia. The accompanying chart indicates the impor-tant features of each case history. A sum-mary of the entire group shows that of thirty squamous cell carcinomas of the esophagus, nineteen were considered opera-ble and were resected, an operability rate in this group of 63.3 per cent. In the group of nineteen resections, there were eight postoperative deaths, an operative mortal-ity of 42 per cent. The causes of death are listed in the chart. There were thirteen Torek or modified Torek operations with six deaths and six anastomosis operations with two deaths, with a comparable mortal-ity rate of 46 and 33.3 per cent, respec-tively. In the Torek group, only two patients are alive and well today, one al-most five years and the other thirteen months postoperatively. In the anastomosis group of four operative survivors, all are alive and well, two and one-half years, two years, eight months, and five months, respectively.

In the group of adenocarcinoma of the cardia with esophageal involvement, there were twenty-four cases. Nine were found operable and subjected to radical resection and anastomosis. The operability rate was 37.5 per cent. There were four operative deaths, a mortality rate in the adenocarci-noma group of 44.4 per cent. Of the five operative survivors, four are alive and apparently free of disease sixteen months, fifteen months, six months, and five

months, respectively. The fifth patient died of retroperitoneal recurrence one and one-half years after operation.

If we combine the adenocarcinomas of the cardia and the squamous cell tumors of the distal esophagus into one group, it will be seen that the operation of transthoracic resection with esophagogastrostomy was carried out in fifteen cases. There were six deaths, an operative mortality of 40 per cent. Eight of the operative survivors are alive and well for periods ranging from two and one-half years to five months.

The general problem of the surgical treatment of cancer of the esophagus may, on the basis of the experiences above described, be reduced to cold figures. The average patient with a cancer of the middle third of the organ stands a 54 per cent chance of surviving the operation and a 30 per cent chance of living more than one year. With squamous cell cancer of the distal third of the organ, the patient has an approximate 70 per cent chance of surviving the operation and almost 100 per cent probability of living more than two years. In the group of adenocarcinoma of the cardia, the probability of operability is only about 37 per cent. There is a 60 per cent chance of operative survival and an 80 per cent probability of living more than one year.

Such is the present status of the operative treatment of this disease. The figures presented indicate a great advance over those given heretofore for the treatment of this disease by other methods. However, there is much to be desired. I am firmly convinced that the operability percentage, the mortality rate and the postoperative survival period will be markedly improved when more early cases are referred for operation and with increasing experience in the operative management.

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RESUSCITATION FOR CARDIAC STANDSTILL AND VENTRICULAR FIBRILLATION OCCURRING DURING OPERATION*

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THIS discussion concerns the resuscitation of patients who die in the operating room. The type of death under discussion is that which occurs unexpectedly. It occurs in the patient who possesses normal heart and lungs. Its occurrence in a healthy patient is not unlike turning off the ignition in a good motor. A vital spark is lost in an otherwise good mechanism. Fortunately, this type of death does not occur frequently. When it does occur, however, the stake is high. I can recall several instances in my own experience. The first one happened twenty years ago when I was a surgical intern in one of the hospitals in Baltimore. A pulmotor was brought to the operating room by the fire department. The patient could not be revived. Unsuccessful attempts at resuscitation take place in the operating rooms the world over. My belief is that surgeons should not turn these emergencies over to the care of the fire department. We should take care of them ourselves. To do so requires a program of action established before the emergency occurs and put into use as soon as the emergency appears. Training in resuscitation should become a part of the surgical curriculum.

In order to take care of these emergencies we must have a proper appreciation of the oxygen requirements to sustain cell life for which an almost constant supply of oxygen is necessary. The supply of oxygen can be interrupted for only a few minutes and then the flame of life goes out. Life can be restored if the interruption in the oxygen system is brief. The safe period for the human being is not definitely known but animal experimentation places it at three to five minutes.[1] The respiratory center rapidly loses its function if it is deprived of oxygen for longer periods of time. If respiratory function can be restored later on, resuscitation is possible. If it cannot be restored later on, then, of course, full recovery is impossible even though the heart action has been restored. Effective effort must be made to re-establish the oxygen system before respiratory loss becomes permanent. There is no place here for trial and error experimentation. When the emergency arises, proper steps must be taken without deliberation and delay.

The Oxygen System. The oxygen system includes respiration and circulation. (Fig. 1.) These two components are interdependent in transporting oxygen to the living cell. Whether respiration fails first or whether circulation fails first is of little consequence in resuscitation. The loss of either is equally destructive to the supply of oxygen to the cell and to cell life.

Respiration. The lungs must be ventilated properly for successful resuscitation. The methods of Schaefer and of Sylvester are valuable for resuscitation from drowning and can be used anywhere in the open country. However, these boy-scout methods of chest compression do not meet the demands of resuscitation in the operating room. Likewise the Drinker respirator is not satisfactory for this purpose. A constant stream of oxygen delivered into the lungs through an intratracheal catheter does not provide satisfactory ventilation of

the lungs. Intermittent compression of a gas bag by hand does not meet the requirements. The only satisfactory method is one

dogs were anesthetized in this way; the chest was opened and intrathoracic operations were carried out. *On the basis of this*
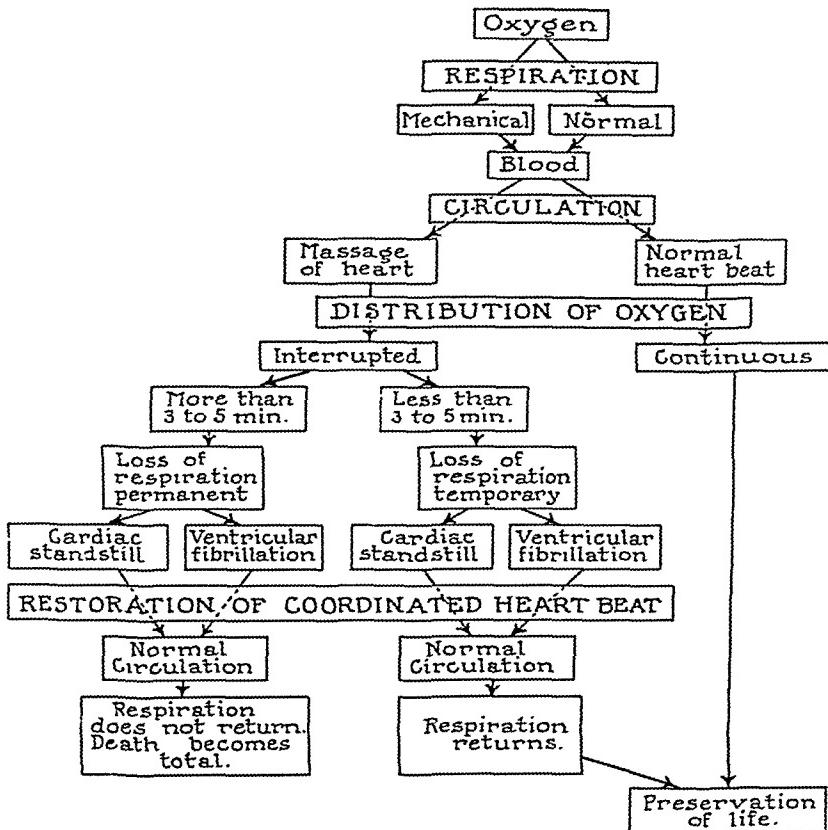
OXYGEN AND RESUSCITATION

FIG. 1. This chart indicates the transfer of oxygen from the outside air to the inside structures of the body.

which intermittently fully distends the lungs and collapses the lungs and which operates in such a way that the surgeon can drape an operative field, open the chest and provide circulation by massage of the heart. For many years these requirements were met in experimental laboratories by several types of apparatuses which intermittently inflated and deflated the lungs. In our laboratory we used an intermittent current of air passed through an ether bottle and delivered into the lungs through an intratracheal tube. A windshield wiper device was used to make the current of air intermittent. A vent was placed in the tube to allow the lungs to deflate without obstruction. The volume of air sent in and the rate were easily regulated. Thousands of

experience we can say that mechanical respiration if properly adjusted performs the function of pulmonary ventilation more thoroughly than does normal respiration.

A few years ago I began to use this apparatus on patients with increased intracranial pressure. I have carried several patients through brain tumor operations with this type of mechanical respiration after the respiratory center was thrown out of function. The introduction of mechanical respiration into our hospitals has been slow. There are few hospitals that possess an apparatus that can provide respiration if failure should occur during an operation on the brain, chest or abdomen. There are, indeed, few surgeons who appreciate the need for perfect mechanical respiration and

for purposes of resuscitation the respiration must be perfect. I learned what constitutes satisfactory pulmonary ventilation from

practical. (Fig. 2.) It is a closed system and uses a gas bag which is part of the equipment of the standard anesthetic machines
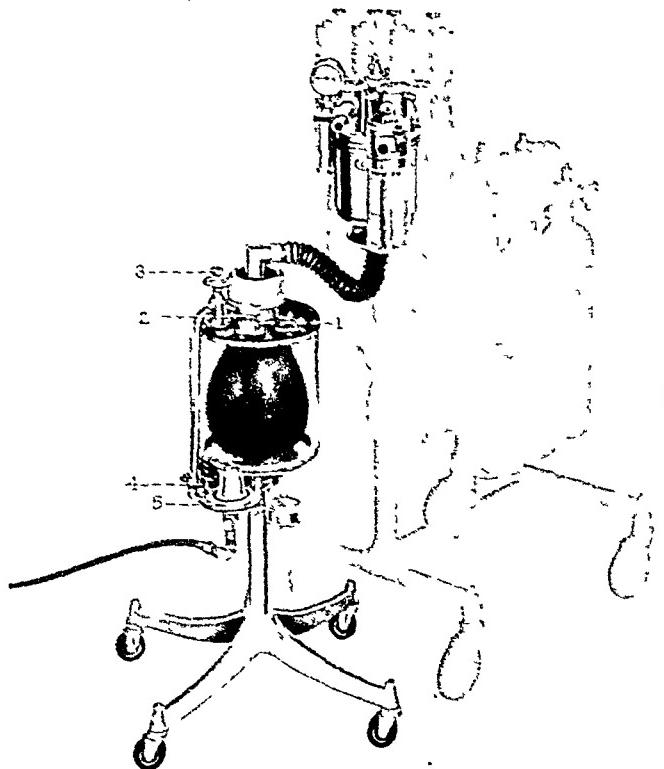
FIG. 2. The Mautz respirator, a mechanism for the intermittent compression of the breathing bag. The tube beneath the glass chamber connects to an air pressure line. This feeds air to an interrupter which works automatically and delivers air into the chamber under pressure and then allows air to escape from the chamber. The gas bag is thereby automatically compressed and delivers its contained gases into the lungs. A container of soda lime in the circuit absorbs the carbon dioxide. The gas bag can be filled with oxygen or other gases as desired. 1 is the valve which connects or disconnects the intermittent pressure by closing the chamber or opening it to the atmosphere; 2 is the pressure-limiting valve which accurately limits the pressure applied to the breathing bag; 3 is the rate control; 14 to 28 alternations per minute; 4 is a windshield wiper device which intermittently opens and closes valve in the bottom of chamber and regulates the alternations when valve 1 is closed. 5 is the reducing valve to regulate the air pressure to 4 lb. per sq. in., the pressure for which the device is calibrated.

my experience in resuscitating dogs. Without this experience I would not have learned this lesson.

There are several forms of apparatuses that can provide perfect mechanical respiration. Crafoord[2] and Mautz[3] each have devised mechanical respirators that meet the requirements. The Mautz apparatus, with which I am familiar, is simple and

in common use. The gas bag is enclosed in a glass box. A mechanical device forces air into the box which in turn compresses the gas bag and this in turn expels its contained oxygen or anesthetic mixture into the lungs. The pressure in the glass container is then released automatically and the gas returns from the lungs to the rubber bag. Soda lime absorbs the carbon dioxide. A

pressure of 12 to 14 mm. of mercury will expand the lungs nicely. It is not always necessary to use an intratracheal tube. Crafoord emphasized the importance of free, unobstructed expiration in order to get rid of carbon dioxide. He pointed out that retention of carbon dioxide produces cardiac dilatation and failure even though plenty of oxygen is delivered to the lungs. He also discussed the fact that the machine takes over respiration and rests the muscles of respiration. This reduces the amount of oxygen consumed by the patient.* If the Mautz or Crafoord apparatus is not available, I would suggest that the inexpensive type of wind shield interrupter be used. I believe that every operating room should have available an apparatus that provides satisfactory mechanical respiration. To have it in working condition and to have it correctly adjusted the apparatus should be used almost routinely. We use it freely on patients when there is no need for it because we desire our anesthetists to be familiar with it.

When to Use Mechanical Respiration. It is obvious that respiration should be taken over by the machine as soon as evidence of poor ventilation appears. As a rule there is a warning before the oxygen system breaks down completely. A critical point is reached when the respiration becomes shallow and irregular and when the heart beat begins to lose its force. If good ventilation can be given at this point, the crisis sometimes can be averted. Much depends upon the supply of oxygen to the heart. Repeatedly in experimental work with the chest open we have observed the heart to recover its strength immediately after the lungs were properly blown up. Anoxemia and accumulation of carbon dioxide weaken the heart action and pro-

duce failure. Conversely, the heart beat is strengthened when plenty of oxygen is supplied and the carbon dioxide is removed.

It is also obvious that getting the oxygen in is of no value if there is not any circulation. If the circulation has disappeared, it becomes necessary to provide artificial circulation by massage of the heart. Mechanical respiration and circulation by cardiac massage are equally necessary to get oxygen to the vital brain cells.

Circulation. When the heart stops beating, the organ either comes to a complete cessation of activity or the ventricular muscle fibers undergo fibrillary twitchings for a variable period of time and then these fibrillary twitchings disappear. The method of restoration of the heart beat is not the same in each of these conditions and it is necessary to determine which condition is present before attempting to restore the beat. The first requirement, however, is not restoration of the beat but the moving of oxygen into the brain. This must be done before the brain centers disintegrate. As soon as the heart stops, action must be taken by the surgeon or his assistant. The chest is rapidly prepared for operation. An incision is made between two ribs over the precordium and the chest is opened. Costal cartilages, one above and one below, are cut across. A retractor is placed. The pericardium is widely opened. A hand is hurriedly placed on the heart and the heart is emptied of its blood. Active massage, about forty times a minute, is carried out. When this point has been reached the crisis has been passed and the need for quick action no longer exists. After a few minutes the operator observes the heart to determine whether or not it is fibrillating. The lungs are inspected to make sure that they are coming well up with each inspiration and that the deflation is also satisfactory. If all is well, the heart muscle becomes pink and regains its tone. It may start beating. If it does not start beating, restoration of the beat is the next problem to be undertaken. To do this some special training or experience is helpful. If a member of the

* One can appreciate the energy expended in breathing by entering the chamber devised by Dr. Alvan Barach of the Medical Center, New York.[4] In this chamber the pressure alternately rises and falls. When one enters this chamber the respiratory effort ceases and respiration is taken over by the chamber. The degree of relaxation and rest that one experiences in this chamber is remarkable.

staff possesses this experience, time can be taken to call him for this task.

Ventricular Standstill. Good ventilation of the lungs before the heart stops beating frequently will avert this type of failure. After the heart stops beating, pulmonary ventilation is not effective because oxygen is not transmitted from the lungs. Epinephrine injected into the heart through the chest wall might start it beating. The needle prick of the heart might produce a contraction. Compression over the precordium is sometimes effective. But these steps have usually been taken before the heart has actually stopped and time is not to be taken in waiting to see whether the heart will start again. The heart is exposed for massage.

If it does not start with direct massage, a small dose of epinephrine is injected into the blood stream. We use 1 cc. of a 1 :1000 solution of epinephrine diluted in 10 cc. of sodium chloride solution and inject it into the cavity of the right ventricle or auricle. Massage is continued. This dose may be repeated. If the lungs are well ventilated, the heart will always start beating. The body should be kept warm with external heat. The heart should not be allowed to cool and warm saline is dripped upon it. If the brain revives immediately, an anesthetic may be necessary while the wound is being closed.

Ventricular Fibrillation. As a rule ventricular fibrillation cannot be made to disappear by massage and the use of epinephrine. In our experience the most effective method consists in the use of procaine followed by an electric shock. Five cc. of 2 per cent procaine are injected into the cavity of the right auricle or right ventricle. Massage of the heart moves the drug through the lungs, left side of the heart, aorta, coronary arteries and myocardial bed. The effect of the drug upon the myocardium is a reduction in its tone and a reduction in its irritability. The heart feels more flabby in the hand and it also dilates after the use of the drug. Large doses should not be used. Two large electrodes of

metal are placed one on each side of the heart and a shock of one to one and one-half amperes is sent into the myocardium. The current is ordinary electric light current with sufficient resistance in the current to reduce the amperage. The current is made and then broken after a fraction of a second. The current brings the muscle fibers into a state of contraction. When they relax they may not show any movement. Not infrequently the fibers go back into the state of fibrillation and the shock must be repeated. If the heart is flabby and shows no inclination to contract, 1 cc. of epinephrine is used. This increases the tonus and the heart can be felt writhing in one's hand. The heart is again shocked. It ought to start if conditions are right. If it does not start to beat, the lungs are inspected to make certain that they are properly ventilated. We have also used 1 per cent calcium chloride in doses of 5 cc. injected into the cavity of the right ventricle. Calcium chloride and epinephrine each increases the tone of the heart muscle, reduces the degree of dilatation and stimulates the fibers to contract. These drugs also tend to preserve the state of fibrillation but this is not always true. We are cautious in the use of these drugs while fibrillation persists. However, we use either epinephrine or calcium chloride if the heart shows no disposition to beat after the use of procaine and electric shock.

The heart can be defibrillated. These methods are effective. It may require several attempts but if conditions are proper, such as the amount of oxygen, the tonus of the heart muscle and the irritability, the co-ordinated beat can be restored.

While all this is being done the body must be kept warm by external heat. Mechanical respiration is continued as long as necessary.

Results. Numerous reports of successful resuscitation are in the literature. These were in patients in whom ventricular standstill was present. In so far as I know the only successful attempts to defibrillate the human heart were in two patients by Beck.

In each of these patients the respiratory center was dead and did not revive. A co-ordinated heart beat was restored in each of these patients but the patients were lost because vital centers had disintegrated before the oxygen system was restored.

CASE REPORTS

CASE I. E. J., a Negro boy, aged nine years, had sustained an injury to the knee. An operation was done to remove a fragment of bone from the knee joint on December 7, 1938. The anesthetic was nitrogen monoxide and ether. The patient was kept in a light zone of anesthesia throughout. At 9:15 the skin was being sutured and the operation was practically completed. The respiratory rate was 19 per minute. At 9:20 the pulse suddenly became weak. Two minutes later it was impossible to get the blood pressure and the respiratory rate was 4 per minute. At 9:25 the pulse could not be felt. The pulse disappeared before respiration stopped. An intratracheal tube was inserted after respiration ceased, and mechanical respiration was given by the respirator. I came on the scene at about 9:32. Dr. J. A. Clark, the surgeon, stated that the pulse had been absent for about eight or nine minutes. This agrees with the time given by the anesthetist. The preparation of the field was done by Dr. Clark while I put on gloves and a gown. It required a few seconds to open the chest. The heart was massaged several times with the pericardium intact. The pericardium was then opened, and the heart was observed. The ventricles showed a coarse, slow type of fibrillation. The heart was dilated but time was not taken to determine the degree of dilatation. Rhythmic compression and relaxation of the heart by hand was done for about twenty minutes. This mechanical circulation produced a palpable pulse over the temporal artery. Never did the wink reflex return. The pupils were dilated and failed to react. Heat was applied to the body. Five cc. of 2 per cent procaine hydrochloride was injected into the cavity of the right auricle. The circulation was kept up by the hand. Large electrodes were placed on the ventricle, and a shock of about 1.5 amperes was sent through the heart. Three shocks were used. They produced forceful jerks of the body. The fibrillation stopped after these shocks. The heart was in standstill. The heart muscle was flabby in the

hand and was without normal tonus. Epinephrine hydrochloride was injected into the blood through the right auricle and massage was continued. The heart remained flabby. Five cc. of 1 per cent solution of calcium chloride was injected. The heart remained flabby. It was then noted that the lungs were not properly inflated and that the tube was not in the trachea. It is probable that it slipped out when the patient jerked with the application of the electrical shock. The tube was inserted in the trachea and the lungs were properly expanded. The interval between the shocks and the discovery that the tube was out of the trachea was about ten minutes. There were a few moments of good aeration and then the heart started up in a forceful rhythmic contraction of 70 per minute. This occurred at 10:12, forty-seven minutes after the pulse disappeared. The radial pulse was easily palpable. The heart was observed for twenty minutes, and the incision in the chest was closed. The pulse later became weaker. There was no reflex at any time. The pulse disappeared at 12:00 o'clock. Necropsy showed no anatomic cause of death.

CASE II. F. B., a Negro boy, thirteen years old, had ptosis of the right eyelid following an injury. Transplant of fascia lata for correction of the ptosis was carried out on July 27, 1939. The anesthetic was nitrogen monoxide and ether. As the last silk suture completing the operation was about to be placed, the operator was informed by the anesthetist that respiration was not normal. At 9:22 respiration had ceased; the pulse rate was 30 per minute. At 9:26 the pulse could not be obtained. An airway was inserted into the pharynx. Epinephrine hydrochloride was injected into the heart. The patient was placed in a Drinker respirator, but it was impossible to expose the heart and provide circulation with the patient in this respirator. He was taken out and given mechanical respiration by means of the Mautz respirator. At 10:05 the heart was exposed by Dr. John Thornton, who at 10:09 began to move the blood by hand. The tone of the heart improved, and for forty-five seconds he obtained what he thought were weak co-ordinated contractions. These were replaced by fibrillary movements. Dr. Thornton sent a current through the heart but it did not stop the fibrillation. Dr. Thornton continued to produce circulation by manual massage of the heart. At approxi-

mately 10:45 I was asked whether I would like to try to defibrillate the ventricles of the heart. I found coarse fibrillary movements of the ventricles; it was obvious to any one that the ventricles were fibrillating. The manual emptying of the heart expelled sufficient blood to produce a palpable temporal pulse. About 2 cc. of 2 per cent procaine hydrochloride was injected into the blood through the right auricle. The heart was flabby. An electrical shock was sent through the heart about five times. This did not destroy the fibrillary movements. The heart was very flabby but of good color. Solution of calcium chloride was given through the right auricle. This improved the tone but fibrillation continued. I desired to increase tone and irritability, and, contrary to past experience, I gave some epinephrine. This increased the tone and I could feel the heart squirming in my hand. After a few moments the heart was beating. Fibrillation had dropped out and was replaced by a co-ordinated contraction at 11:05. Epinephrine hydrochloride was given in an intravenous drip. The incision was closed. An electrocardiogram showed auricular fibrillation, right bundle branch block and right axis deviation. The radial pulse was felt easily. There were no reflex responses. Mechanical respiration was carried out throughout. The pulse continued until 3:00 o'clock when it disappeared.

I should like to refer to Prevost and Battelli[5] for the introduction of the electric shock for defibrillation of the ventricles, to Wiggers[6] and to Hooker[7] for physiological studies in ventricular fibrillation and to Mautz[8] for the introduction of procaine to reduce the irritability of the heart. Reports in the literature on cardiac massage[9] are very numerous. The majority of these are from England and were in patients who were given chloroform.

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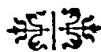
THE TREATMENT OF INJURIES TO THE CHEST*

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INTRODUCTION

IN the present war the casualties among the civilian populations are so widespread it is most timely that we discuss chest injuries with reference to their occurrence and management in modern warfare, as well as the treatment of them in everyday life.

At the December, 1940, meeting of the Royal Society of Medicine, Mr. Thomas in his discussion quoted Hoche's review of 11,000,000 English, French, American and German wounded:

DISTRIBUTION OF WOUNDS

	Per Cent
Limbs..	68
Head, face, neck	15
Spine and cord	4
Pelvis ..	3
Thorax	6
Abdomen	4

MORTALITY IN ABOVE SERIES

	Per Cent
Total mortality	8
Wounds of abdomen	68
Wounds of thorax	56

WOUND DISTRIBUTION AMONG 12,350 KILLED

	Per Cent
Head	47
Thorax	20
Abdomen and pelvis	11 8
Limbs.. .	9 9

The high immediate and late mortality of wounds of the thorax is evident from the above tables. Patients with injuries of the chest suffer from the same shock, hemorrhage and sepsis as those with wounds elsewhere, *plus* special factors which interfere with their respiratory and cardiorespiratory function and reserve. These are: (1) air and blood in one or both pleural cavities, frequently under increasing tension; (2) open pneumothorax with lung collapse, mediastinal flutter, paradoxical respiration with swing of the intrapulmonary air from one lung to the other and loss of the aspiratory effect on the great veins with decreased cardiac output; (3) cardiac tamponade, and (4) surgical emphysema—sometimes progressive. All of these features become accentuated in older people and in those with existing lung or heart pathology.

As mentioned in previous papers, since all injuries of the chest imply a potential pleural, lung or heart involvement the respiratory mechanism should be considered as consisting of three components: (1) The purely volumetric or spatial attributes of the thoracic cage, bronchial tree and lungs: their structure, vital capacity, tidal and reserve air, and the rôle they play in pulmonary ventilation; (2) the intrapulmonary function of gas exchange, and (3) the very important cardiopulmonary relationship. The two primary principles, therefore, in treating these wounds are, *first* the immediate treatment of the shock and hemorrhage by the proper administration of fluids—whole blood, plasma or serum, and crystalloids—together with the use of 100 per cent oxygen, and, *second* the restoration and maintenance of the normal anatomy and physiology of the cardiorespiratory mechanism as soon as this is possible. Depending upon the individual case and the conditions presenting as in active hemorrhage, extensive wounds of the thoracic wall and wounds of the heart and pericardium, the treatment of shock and hemorrhage and of the injury itself are carried out simultaneously.

GENERAL TREATMENT OF INJURIES

Before taking up specific types of wounds certain basic factors of treatment should be understood. First, almost all patients with

wounds of the thorax suffer from shock and some also from hemorrhage. If there is a sucking wound present, this should be promptly sealed with a sterile pad strapped snugly in place, or, if this is not available, with anything at hand. Hemorrhage from intercostal vessels or the parietes may be temporarily controlled by a mushroom type of pack which is inserted into the wound and pulled outward, thus exerting pressure from the inside. The Shaeffer method of artificial respiration should be used with care as the manipulation may cause further injury to the chest wall or lungs. The legs should be elevated to combat shock and the patient transported in the Trendelenburg position unless it is evident that this causes respiratory embarrassment, in which case the head of the stretcher should be slightly elevated. The patient should be placed in bed with the head slightly elevated and as soon as possible a transfusion of whole blood or plasma given and 100 per cent oxygen administered. This may be done by the use of a B L B (Boothby, Lovelace, Bulbulian) type of mask, an oxygen tent if available, or failing these, nasal oxygen by catheter, or if necessary by attaching an anaesthesia bag over the canister of a gas mask or respirator and connecting this with an oxygen tank, as suggested by Marriott. Four or five liters a minute may be comfortably given by nasal catheter and about eight or nine liters with the B L B mask or the transformed respirator. Of these the catheter method is least effective. Morphine should be used as needed to allay pain and fear. It should not be given in such dosage as will depress respiration or productive cough, however, for the maintenance of good pulmonary ventilation and the ability to cough up secretions is essential. In the case of rib fractures, particularly when they are multiple, injections of 2 to 5 per cent novocaine into the intercostal nerves paravertebrally or at the site of fracture are most effective and may be repeated as necessary.

Almost coincident with the above general measures an accurate history should be obtained, postero-anterior and lateral x-rays of the chest taken in as near an upright position as possible and a careful physical examination made with certain rather general findings in mind. Any asymmetry, deformity, fulness or unequal motions of the chest should be noted. Also the position of the trachea, the apex of the heart and cardiac dulness and the level of dulness from fluid in the chest should be ascertained. Auscultation is important especially with reference to the heart and the possibility of cardiac tamponade, and likewise for the detection of intestinal sounds in the chest, as well as the signs of fluid or air in the pleural cavity. Blood pressure determinations should of course be obtained. Not infrequently the abdomen is held rigidly in wounds of the lower chest and here the decision must be made as to whether or not there is accompanying intra-abdominal, renal or spinal injury, sometimes an extremely difficult differentiation.

WOUNDS REQUIRING IMMEDIATE OPERATION

There are certain indications for immediate operative intervention, the most urgent of which is a wound of the heart with acute cardiac compression. This is first suggested by wounds close to the sternum and the diagnosis is made by (1) a falling or absent blood pressure, (2) distended veins of the neck with increased venous pressure, and (3) a silent heart by auscultation and by fluoroscopy. The patient also presents a rather grayish cyanosis. Prompt intervention is urgent with repair of the cardiac wound and thorough irrigation with warm saline, a transfusion of blood or plasma and oxygen therapy. Opening of the pleura is to be avoided and the wound is carefully closed. Aspiration of the pericardium may be tried as a temporary expedient to relieve the tamponade although one must remember that such relief of tamponade may permit active bleeding again from the wound in the heart. The sulfonamides should not be used directly in the pericardial cavity because of the marked fluid

response they provoke when employed locally in serous cavities or in the tissues.

Progressing hemorrhage requires operation. Generally, this is due to injured intercostal or internal mammary vessels, less often to trauma of the lung itself. Lung wounds, after the initial loss of blood, usually seal themselves because of the resulting collapse of the lung and the pneumohemothorax which ensue. Occasionally, however, if one of the larger vessels is damaged, open thoracotomy and suture or resection of the affected lobe may be required. Wounds of entrance and exit should be carefully explored so that the intercostal vessels may be carefully inspected as these are the usual sources of persisting hemorrhage. Foreign bodies and fragments of bone should be completely removed, the rib ends left smooth, the wounds débrided and the chest closed. Closed intercostal drainage should be established with suction up to 12 cm. of water if possible. If available, sterile sulfanilamide or sulfathiazole powder may be left in the pleural cavity and soft parts in 6, 8 or 10 Gm. amounts as prophylaxis against infection.

Sucking wounds of the chest demand immediate operation. The same meticulous wound toilet should be performed as just described. If the defect cannot be entirely closed, the muscles and skin should be drawn together as well as possible, the lung sutured snugly into the remaining opening and dependent closed drainage established (Barrett). A sterile vaseline gauze dressing is applied over the wound and strapped firmly in place so as to provide an aseptic, airtight covering.

Compound fractures of the ribs and wounds of the soft parts of any magnitude require débridement and closure if seen within the first eight hours. If there is any question about the wisdom of primary closure, the muscles may be sutured and the skin left open about a sterile vaseline gauze pack and later a secondary suture used if necessary. If large or grossly contaminated foreign bodies are present in the pleural cavity or lungs, they should be removed as soon as practicable as they are prone to cause hemorrhage and infection. If an injury to the diaphragm is suspected or if one is found in the course of wound exploration for one of the above reasons, the wound in the diaphragm should first be enlarged and the upper abdominal viscera examined for injury; only after this has been done should the diaphragmatic rent be repaired. Depending upon the amount of intraperitoneal damage it may or may not be necessary to open the abdomen as well as the chest.

In the convalescence from these procedures reliance is placed first on ample oxygen therapy and transfusions, then on a full diet rich in vitamins and on the sulfonamides for pneumonia or infection. A free airway and lung ventilation is of the utmost importance in the prevention of atelectasis and pneumonia. If the patient is unable to get rid of accumulated secretions, these should be aspirated as often as required by a catheter passed through the nose into the trachea and suction applied. This simple procedure may eliminate the need for bronchoscopy or may be used to supplement it. Fluid collections must be looked for and removed and the drainage tube kept open. Every effort should be made to facilitate early re-expansion of the lung and restoration of the individual to normal. Fluid accumulations, sepsis, pneumonia and secondary hemorrhages are the most common complications. In the absence of infection we have found suction up to 12 or 15 cm. of water an aid in re-expansion of the lung. If this is not available, the cavity may be washed with oxygen and the drainage tube then clamped for twelve to twenty-four hours and the process repeated. As the oxygen is absorbed an increasing negative pressure develops with resultant pull on the lung. If the lung expands well and there is but a small amount of serous drainage, the tube may be removed in a week. If sepsis develops, however, wide open drainage is established as soon as walling off has occurred sufficient to stabi-

lize the mediastinum. The cavity may be packed for a few days or suction may again be established. This helps keep the dressings dry, and, with dressings closely applied about the tube, will maintain an increasing degree of differential pressure. The presence of a bronchial fistula in no wise contraindicates the employment of suction. Later in the convalescence, physiotherapy and breathing and postural exercises are exceedingly helpful in restoration of the mobility of the thorax and expansibility and expansion of the lung, thus preventing fibrosis of both lung and pleura, scoliosis and deformity of the thoracic cage.

HEMOTHORAX

According to Edwards and Davies about 70 per cent of all chest wounds are complicated by hemothorax. This was the topic of an entire evening's discussion by the Royal Society in December, 1940. All agreed that when it is present with wounds like those just described débridement and thoracotomy is the indicated treatment. Frequently it occurs following crushing injuries of the chest with simple rib fractures and almost always it accompanies penetrating gunshot wounds and then may be called a "compound" hemothorax. In civil life these penetrating wounds are commonly made by small objects such as icepicks, small knives or bullets; in war they usually result from bullets and shell fragments. A compound hemothorax with small clean wounds of entrance and exit as from rifle or machine gun bullets and small penetrating shrapnel fragments or stab wounds, should be treated like a simple closed pneumothorax. We have preached this for many years and I have referred to it in two previous articles. The important principle of therapy is aspiration with air replacement. Weeks, in his work with the New York police force, corroborates this, for he found that seventy-six gunshot wounds of the chest, treated without or with late aspiration, had a 26 per cent mortality, whereas in seventeen treated with early aspiration and air replacement

there was no mortality, complete lung reexpansion in all and early return to duty. The unanimous opinion of this meeting of the Royal Society was in favor of this method of handling these cases and a similar opinion was recently expressed by Bumm, in Germany. When blood is present in the pleural cavity, an immediate inflammatory reaction of the pleura is produced with congestion and edema, copious fluid secretion and deposition in fibrin on both the parietal and visceral surfaces. This collection of blood and fluid increases the danger of infection, atelectasis and pneumonia. It absorbs slowly and unevenly with frequent loculations and sometimes the lung never completely re-expands. The result is an incapacitating fibrothorax, occasionally with deposition of calcium, with deformity of the chest and marked dysfunction of the affected lung from fibrosis, compensatory emphysema of the opposite lung and displacement of the mediastinal structures to the affected side. Thus the spatial and cardiorespiratory components of cardiopulmonary function may be severely damaged and such patients become permanently incapacitated. (Fig. 1.)

After the initial treatment of the shock and hemorrhage, dyspnea and cyanosis due to tension pneumothorax or fluid accumulation with mediastinal displacement must be relieved by repeated aspirations or the establishment of closed drainage. Roentgenograms should be made in the upright position and in interpreting these it is well to remember that the diaphragm on the affected side is usually elevated and that blood clot and air occasionally give a picture resembling coils of intestines. Livingstone suggests giving a glass of water with 4 Gm. of sodium bicarbonate before the x-ray to outline the diaphragm more clearly when the lesion is on the left. Barring emergency aspiration the chest should be aspirated in from twelve to forty-eight hours, and *all* the fluid removed and replaced with an equal amount of air. Such aspiration is threefold in purpose: (1) It is

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an important diagnostic aid; (2) it prevents infection, and (3) it insures an early return of normal function. This should be repeated

are best performed with a large needle (14 to 16 gauge) attached to a two-way stop-cock on the syringe so that as the fluid is
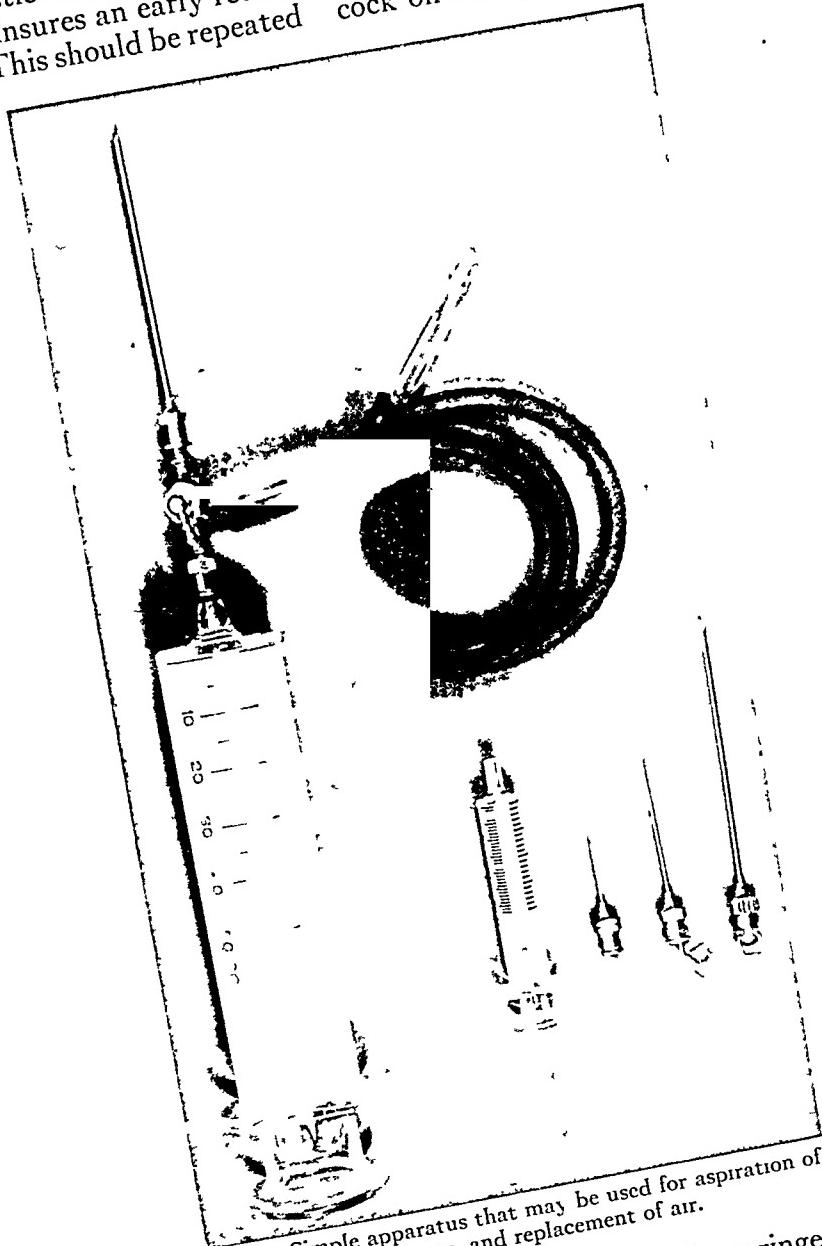
FIG. 1. Simple apparatus that may be used for aspiration of hemothorax and replacement of air.

as often as fluid reaccumulates in sufficient amounts to cover the diaphragm. One tube of fluid removed should be sent to the laboratory for direct smears and cultures and a second kept at the bedside for future comparison. Furthermore, unless this fluid is removed collapse of the lower lobe and even large foreign bodies may be quite hidden by the fluid shadow. These aspirations

removed the syringe need not be disconnected as it is filled with the air that is to be put back into the chest. Open thoracotomy is indicated if a foreign body of appreciable size is present, if infection develops or if it is noted that the clot cannot be removed and the pleura is becoming thick so that the lung fails to re-expand. No permanent pneumothorax should be left

—sterile or infected—for this is a source of future trouble and loss of function. The lung and chest wall *must* be brought into complete apposition by full expansion of the lung if possible. If this fails, a decortication or collapsing operation on the chest wall should be performed. An unexpanded pneumothorax is a potential source of trouble and should never be allowed to remain.

NONPENETRATING WOUNDS

Nonpenetrating wounds of the chest may vary in extent from slight contusion of the chest wall to extensive crushing with multiple rib fractures and tear of the underlying lungs. Such injuries are common among persons buried in débris, in aviation accidents and in sudden crushing injuries as when the victim is caught between a truck and a wall. Even simple contusion may cause an accumulation of clear fluid or an underlying atelectasis or pneumonia. Such sequelae are more likely in the aged or in those with existing pulmonary pathology. If ribs are fractured and the lung torn, a traumatic tension pneumothorax may develop rapidly and demand prompt relief. Frequently a hemothorax appears which should be evacuated and treated as already outlined. Subcutaneous emphysema is commonly present and usually absorbs spontaneously; if, however, it becomes so extensive in the neck as to endanger respiration, incisions should be made in the lower neck and the carotid sheaths opened.

Flying objects with violent impact on the chest wall may cause serious hemorrhage and laceration in the lung directly beneath the blow. Following a severe crushing of the chest there may be multiple rib fractures, which Barrett calls the "stove-in" type. These injuries may be complicated by a traumatic asphyxia or an acute dilatation of the stomach with inability to get rid of the vomitus, which in turn favors the development of pneumonia and pulmonary suppuration. In this compression asphyxia the lesions may be symmetrical in both lungs with generalized congestion, some edema and small subpleural hemorrhage and sometimes emphysema along the lines of the ribs; or there may be laceration or fracture of the trachea, bronchi or lungs.

I have recently had under my care a patient who sustained a fracture of his right main bronchus following a severe crush of his chest five years previously. This resulted in an almost complete atresia of the bronchus with repeated attacks of acute suppurative pneumonitis. The old fracture was demonstrated at operation. A subtotal pneumonectomy and later a thoracoplasty were performed with recovery. In all such injuries adequate pulmonary ventilation is best maintained by strapping the affected side to allay pain and control paradoxical respiration, injecting the intercostal nerves with novocaine to promote free respiration, and oxygen therapy of 60 per cent or more. Intra-abdominal or retroperitoneal lesions should always be looked for and may be extremely difficult to exclude because a rigid abdomen is common to all. Also, blunt cardiac trauma should always be suspected in these injuries and careful note made of pain distribution, blood pressure, quality of heart sounds, rhythm and murmurs, and electrocardiograms should be made at frequent intervals if possible. If evidence of heart injury is found, absolute rest and oxygen therapy should be instituted just as in the treatment of coronary thrombosis.

BLAST INJURIES

In the English literature considerable attention has been given to the blast injury or concussion and cases have been reported in detail by Dean and Thomas, Falla, Fallon, and Hadfield and Christie. The first experimental work was reported in 1924 by Hooker, who said bruising and rupture of the lungs "were the single gross lesions found postmortem after exposure to air concussion due to gun-blast or high explosive." Blast produces a sudden marked fall of arterial and venous pressures and a later washing out of venous carbon dioxide. Since the onset of the present war

further studies have been made under the direction of the Home Office by Barcroft with goats, and by Zuckerman with mice, pigeons, guinea pigs, rabbits and monkeys.

Zuckerman's work is of sufficient interest to report in detail. He used a seventy pound charge of high explosive and first explains the physics of a blast. Blast consists of two waves, a compression wave that lasts 0.006 seconds and a suction wave of 0.03 seconds. All pressures are, of course, in excess of the normal atmospheric pressure of fifteen pounds per square inch. The blast wave consists of a shell of compressed gas increasing very rapidly in radius—1500 feet a second at thirty feet for a sixty pound charge. There is an additional wind pressure exerted by this shell of gas *only* in the direction of its motion; hence any surface not directly in its path is subject just to the compression wave. This wave of pressure is highest in the region of the explosion and falls rapidly. At fifteen feet from a 125 pound charge the compression wave carries a pressure of 200 pounds. Close to the explosion the wind pressure may be as great as the pressure of the charge itself but it falls more quickly with distance. Thus everything in the immediate neighborhood of a big bomb is suddenly exposed to a wave of many times the atmospheric pressure, whereas at fifty feet this will be only two or three atmospheres and at 100 feet only a fraction of an atmosphere. The velocity and duration of the pressure wave is such that a human body will be completely immersed in it. The suction wave is much weaker and can never exceed fifteen pounds per square inch, which is a perfect vacuum. The magnitude of the pressure and suction vary directly with the amount of explosive. If an object is not blown apart by the wind and compression waves, it may then be attracted to the center of the explosion by the weaker and longer suction wave.

If the victim of a bomb explosion is not blown apart he may be injured in three ways: (1) by being hit by masonry, fragments or flying objects, (2) by being vio-lently thrown, or (3) by the effect of the blast wave without being thrown. This last is the true blast injury or concussion in which there is no sign of any external injury, and even in this group Roberts warns of confusion with carbon monoxide poisoning.

In his work with animals with the seventy pound blast Zuckerman found that no animals died that were more than eighteen feet from the explosion and none more than fifty feet distant was injured. Furthermore, there was no sign of external injury in any of the animals examined. The outstanding pathological condition consisted of hemorrhages in both lungs and in all lethal cases blood was present in the bronchial tree and air passages. The blood came from torn alveolar capillaries as a rule. There was bruising or tearing of the lungs in the lines of the ribs, this bruising extending for a short distance into the parenchyma. Zuckerman concluded that these pulmonary lesions are caused by the pressure component of the blast by its impact with the body wall. This conclusion was based on the type of lesions found and further on the fact that animals encased in thick sponge rubber suffered little damage from the blast compared with their controls; also animals with one-half of their bodies protected by rubber sustained these lesions only on their unprotected sides when they were exposed with this side facing the blast and not on the protected side when this was the side exposed to the blast.

In the clinical cases similar findings have been recorded. After blast concussion symptoms may be delayed in appearance up to two to five days and consist of tachycardia, restlessness, dyspnea and cough with blood-tinged sputum. The signs are a fulness of the lower chest with diminished movement of the dipahragm, some spasticity of the upper abdomen, dulness and râles at the base of the lungs and a loss of translucency by x-ray with evidence of diminished rib expansion. The treatment is absolute rest, sedation and oxygen therapy.

TRANSPORTATION

In all of these patients with chest injury the possible risks of transportation should be recognized and weighed. The decision must be made with due regard to the personnel and facilities for caring for them. Emergency therapy includes the initial measures for shock and hemorrhage and then an appraisal of the problem at hand as to whether immediate or early surgery is indicated, whether hemothorax should be relieved with air replacement or observation and expectant treatment should be instituted. Here the question of transport enters. It is evident that these patients will have a better prognosis and fewer complications if they can be treated in institutions or centers familiar with and equipped for the care of thoracic surgery and trauma. In war organization such centers can be formed both for the reception of such injuries and for consultation and instruction. In civil life, for the more complicated patients, well equipped hospitals should be utilized and the aid of those interested in thoracic surgery sought.

ANESTHESIA

In all surgery of the chest anesthesia plays a most important rôle; this is particularly true in wounds in which it may be imperative to carry out a major procedure upon a person suffering from hemorrhage and in shock. Induction must be quiet, abundant oxygen must be supplied, effective respiration must be maintained with a free airway and bronchial secretions must be promptly removed. The anesthetist should, in addition, assume the management of the patient during the operation advising as to the extent of the procedure and the need of blood and other fluid. A quiet induction is best assured first, by proper sedation with morphine and scopolamine and perhaps a barbiturate given one-half hour previously. Intravenous pentothal sodium is also an excellent method of rapid and quiet induction. The agent itself may be selected from ether, chloroform,

cyclopropane and ethylene. Of these ether is the safest and best. Both ether and cyclopropane can be used with a high percentage of oxygen but ether is less depressing, less liable to accident, is safer except with a person thoroughly familiar with cyclopropane, and, if properly administered, should produce little if any more irritation. In war and for mobile units ether and chloroform have the further advantage of greater adaptability for supply, storage and transportation. The method of *controlled* respiration with carbon dioxide absorber technic is strongly recommended (Nosworthy). An intratracheal tube inserted under direct vision, or as a Magill tube through the nose, is advised but is not essential as in these cases secretions are usually not a problem; hence an ordinary intrapharyngeal airway will often suffice. Intratracheal anesthesia, however, should be employed when possible, and in any event for all but emergency procedures. This assures better control of respiration and a free airway with the ability to aspirate secretions completely. There should be an airtight fit between mask and face so that the control of respiration may be taken over entirely by the anesthetist. This permits normal physiological respiration to occur even with the chest wide open and completely abolishes paradoxical respiration and mediastinal flutter. It also insures a plentiful supply of oxygen, the removal of carbon dioxide and quiet respiration. Hyperventilation hinders the work of the surgeon and may be harmful both locally to the wounded lung and generally in the washing out of carbon dioxide and accentuation of shock. Controlled respiration likewise allows occasional inflation of the lung during operation and re-expansion of it at the completion of the procedure. An elaborate apparatus is not required for this anesthesia technic and while an absorber is helpful it is not essential. All that is really necessary is an airtight mask with the bag kept not quite fully distended; this will then permit of control of the respiration by rhythmic hand

pressure on the bag. Oxygen therapy should be maintained for at least twenty-four hours postoperatively. It might be pointed out here that many restless and apparently delirious patients will frequently respond most dramatically to oxygen therapy alone for serious anoxia may exist without any cyanosis or dyspnea, particularly in the presence of anemia.

SUMMARY AND CONCLUSIONS

Wounds of the chest and their treatment have been discussed. Almost all are accompanied by some shock. This and hemorrhage when present should be treated before anything else is attempted.

Immediate operative intervention is indicated for wounds of the heart and pericardium, progressing hemorrhage and sucking wounds of the chest. Early operation is also indicated in compound rib fractures, moderate and large wounds of the soft parts, large or infected foreign bodies and possibly wounds of the diaphragm. Simple perforating wounds, unless accompanied by hemorrhage from an intercostal or internal mammary vessel should not be operated upon. Tension pneumothorax should be promptly relieved and subsequently fluid and air removed as indicated.

Traumatic hemothorax should be treated by aspiration and air replacement. Expectant treatment is to be condemned. Operation may be required *later* for sepsis, foreign body or organizing blood clot.

Crushing and nonpenetrating wounds of the chest are discussed. The treatment is primarily conservative with strapping, sedation and novocaine injection of the intercostal nerves. Severe lung or bronchial injuries should be suspected and may require surgery later. Contusion of the heart, rupture of the diaphragm and intra-abdominal injury should likewise be borne in mind.

Blast injury or concussion is considered in detail. The injury is probably a direct contusion of the lungs from the compression wave of the blast, similar to a very severe blow on the chest.

The problem of anesthesia is discussed and an ether-high oxygen mixture administered by the closed system technic with controlled respiration and intratracheal intubation recommended.

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RECENT EXPERIENCE WITH WAR
WOUNDS OF THE CHEST

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DURING the latter part of the last war, much interest became focused on wounds of the chest owing to the new conception that thoracic injuries should be treated on the same principles as wounds elsewhere in the body. The conclusions reached as a result of this fresh outlook have been fully described (Duval,[1] Grégoire and Courcoux,[2] Gask,[3] etc.).

During the subsequent years of peace, steady progress was made in thoracic surgery. It is, therefore, important that we consider in what way this advance has influenced the treatment of chest casualties since the disastrous outbreak of further hostilities. The prelude to the present vast conflagration occurred in Spain and those responsible for the care of chest wounds in the war of 1939 naturally sought the experiences of the surgeons who treated the Spanish casualties. Jolly[4] leaves the impression that few primary intrathoracic operations were performed for he states that "the outlook for all cases requiring an intrathoracic operation is grave" and "a lung abscess developing later in a living man is to be preferred to an aseptic thoracic cavity in a dead one." In general, Jolly recommends the conservative treatment in vogue during the early phases of the 1914 war. It appears, therefore, that no advance in the care of thoracic wounds evolved from the Spanish Civil War.

Although a considerable amount has been written on chest wounds since the outbreak of the present War, most of the opinions expressed are based on experiences of over twenty years ago (Tudor Edwards,[5] etc.). This is partly due to the fact that military casualties have been mercifully few and that chest wounds in civilians resulting from aerial bombardment tend to be severe and often result in death before reaching the hospital. Compared, therefore, with the almost astronomic number of casualties dealt with in the Great War, the experience derived during the last two years has been very limited. However, it is not proposed in this communication to re-state the generally recognised features of war wounds of the chest but to consider any new factors which have arisen and to what extent the last two years have modified or confirmed the 1920 conceptions.

Personnel. If Duval's results with thoracic wounds are compared with those obtained in the latter part of the last war from large sections of the British Army (figures quoted by Gask[3]), it seems at first doubtful if the general adoption of Duval's policy of frequent early surgical intervention in penetrating wounds was justified.

There are many factors which influence individual group results, in particular the nature of the missiles being used and the condition of the soil and men's clothes. But, after adequate allowance has been made for these factors, there remains a discrepancy in results which is at first confusing. This discrepancy is readily explained by the fact that there are very large numbers of general surgeons with excellent training but less than 5 per cent are accustomed to thoracic work. It would be futile to pass comment on this fact if it did not have a direct practical bearing on the treatment of chest injuries. Apart from the obvious conclusion that war calls for a higher percentage of thoracic surgeons and that those existent should be organized into readily available teams, it must also be clear that the treatment of many individual cases must depend upon the thoracic training of the surgeon and, in addition, upon the

facilities for the after-care of such cases. A patient with a penetrating wound may have better prospects of recovery with conservative treatment if those conversant with this region are not available.

Transportation. It is usually stated that the general condition of patients suffering from thoracic injury suffers very severely from transportation. When the wounded, untreated except for the application of dressings, reached England during the evacuation of France, it was thought that patients with severe chest wounds would be unlikely to survive the journey; yet there were a number who did and the general condition of many was not too bad. When the bombing of London started, chest casualties were admitted to many hospitals scattered over the Metropolitan area. A decision had to be made in each case whether the best chance would be given to the patient by operation at the hospital of admission (where he would have to be retained for several days after operation) or by transfer to one of the chest units stationed in hospitals some twenty miles outside the center of the city after adequate resuscitation. As time passed, it became a routine (with few exceptions) to advocate retention at the primary hospital for those who did not require early open operation, e.g., crushing injuries, and the transfer of those who did, as soon as morphia, warmth, blood transfusion, etc., had overcome the initial shock. The only local measures taken prior to transfer were prevention of sucking in open pneumothorax cases and the control of obvious external hemorrhage. The patients suffered very little from the journey. In two cases— a girl of twelve with a thoraco-abdominal wound involving the liver from which she was still bleeding, and a boy of seventeen with the internal mammary artery severed and bleeding into the pleural cavity—it would have been preferable to continue the transfusion during the journey; but, in spite of not doing so, neither patient deteriorated except for a slight further rise of pulse rate. Patients are distressed by movement in bed or from bed to stretcher and vice versa; but, if this is carefully done and the patient made comfortable on the stretcher with the trunk raised to 30 degrees to the horizontal, the journey itself is well tolerated provided the driver realizes the nature of his cargo.

We would, therefore, recommend the transportation of patients requiring primary operation to a hospital where there are proper facilities for treating them, expecially as postoperative care is frequently more important than the operation.

"Blast" or Pulmonary Concussion. During the 1914–1918 war, it was noted on many occasions that men might be found dead in the immediate vicinity of an explosion without external evidence of injury. No satisfactory explanation of this phenomenon was provided although massive pulmonary collapse (Lockwood[6]) and acute carbon-monoxide poisoning were suggested as possible causes. At the onset of this war, Phillips[7] stated that he had performed many postmortem examinations on miners found dead as a result of explosions in the South African gold mines and discovered multiple scattered intrapulmonary hemorrhages. Zuckerman[8,9] then published the results of his experimental work on animals showing that the positive pressure wave of an explosion, acting directly on the chest and abdominal walls, may produce extensive diffuse intrapulmonary hemorrhage. This was found to be the most consistent autopsy finding in animals dead as a result to exposure to "blast." Hadfield[10] and his co-workers later confirmed these findings in man from their examination of victims of aerial bombardment.

Clinically, very few patients have been recognized as suffering from this condition. It would appear that, in man, there is only a very small margin between immediate death and complete escape from "blast" injury. Alternatively, the cases have not been recognized owing to ignorance of the symptoms and signs but this is improbable as there are many observers who have been only too ready to make the diagnosis.

At present, it can only be stated that pulmonary concussion should be suspected in any patient found close to the site of an explosion, particularly if there is cyanosis, marked shock, dyspnea, diffuse chest or abdominal pain, scattered pulmonary râles or abdominal rigidity unaccounted for by any other injury. From the surgical standpoint, two observations are worthy of stress: First, generalized abdominal rigidity of such degree as to precipitate exploratory laparotomy has been observed by O'Reilly[11] and others; this is probably accounted for by associated hemorrhage into the intercostal spaces which causes irritation of the intercostal nerves. Second, there is evidence that the hemorrhage continues for some time after the injury. Inhalation anesthesia, which might otherwise be required for treatment of co-existent injuries, should therefore be avoided if possible.

Closed Injuries. Since the aerial bombardment of the civilian population started, the proportion of closed to penetrating injuries has steadily increased, presumably as a result of the population taking more adequate protection. Damage to the viscera with the thorax without fracture of the bony framework is well recognized, particularly in children owing to the elasticity of their chest wall. We have seen three cases of closed traumatic pneumothorax and three cases of gross pulmonary contusion in the absence of fractured ribs. Similarly, visceral damage may occur when a missile penetrates the soft tissues overlying the thoracic skeleton. For this reason, hemoptysis is not always evidence of penetration of the chest wall.

As regards the diagnosis and treatment of closed fractures of the thorax, there is little to add to the generally accepted views. Provided adhesive strapping used to splint fractured ribs extends at least 3 inches *beyond* the midline anteriorly and posteriorly, there appears to be no necessity for encircling the entire chest which has the disadvantage of diminishing the function of the opposite lung. We have found this to be true with fracture of as many as

eleven ribs on one side and with severe degrees of "stove-in" chest where part of the chest wall moves paradoxically. Theoretically, inelastic strapping provides the best splint but, in practice, elastoplast or its equivalent can be put on more evenly, remains in the applied position longer and can be made to give equal support if slightly stretched. Strapping should be postponed if the patient is severely shocked as the movement entailed in its application may result in dangerous exacerbation of the circulatory depression. During the period of recovery from shock, the patient should be rolled slightly towards the affected side so that respiratory movement is limited on this side and any paradoxical movement is minimal unless situated anteriorly.

Rib fracture with gross displacement of the fragments may be associated with damage to the intercostal vessels giving rise to progressive intrapleural hemorrhage which may necessitate surgical exploration. Serious damage to an upper abdominal viscus may indicate laparotomy. With these two exceptions, it is probable that closed fractures of the ribs even when there is gross comminution and displacement of the fragments, are best treated conservatively, i.e., simply by strapping. We have treated all such cases, including those with evidence of pulmonary damage, in this way and have been surprised at the excellent functional end results. If the patient develops a hemothorax which is not progressive, the blood should be aspirated (with air replacement if necessary). The escape of air from the lung into the pleural cavity may be ignored unless giving rise to respiratory distress. In the latter case, the pneumothorax tension is most easily relieved by inserting a short wide-bore needle into the pleural cavity and connecting it by rubber tubing to a "water-seal" drainage bottle.

Brock[12] has drawn attention to the occasional occurrence of acute dilatation of the stomach in crushing injuries to the chest. Even if there is no vomiting, this complication should be considered when the pa-

tient's general condition is much worse than can otherwise be accounted for. If the lower part of the left side of the chest is the site of injury, delayed rupture of the splenic capsule is a possible contingency. One of our patients developed massive intraperitoneal hemorrhage on the ninth day.

Diaphragmatic herniation should undoubtedly await surgical cure until the patient has otherwise made a complete convalescence.

Sternal fractures may occur apart from those resulting from direct trauma. We were forcibly reminded of this when a *convoy of wounded men was received after* escaping over the cliffs at St. Valery in France. The chief complaint of three of the men was pain on breathing and they were accordingly allocated to the thoracic unit. After admission, examination revealed a transverse fracture of the sternum, in each case complicating crushing fractures of the vertebral bodies which had resulted from their jump from the cliff top.

Penetrating Wounds. In the absence of pleural penetration, there is no comment to make on the well established principles of treatment formulated twenty years ago.

Hemothorax. In patients who do not require primary operation except for excision of entry and exit wounds, e.g., through-and-through bullet wounds, penetration by very small fragments of shell or bomb casing, the treatment of a hemothorax has been revised during the last two years. In the past, it was customary to await absorption of the blood unless the bleeding was progressive or causing respiratory distress from pressure. The disadvantages of such expectant treatment are: (1) An excellent bacterial culture medium remains in the pleural cavity thus encouraging infection and, if it occurs, the consequent empyema is frequently very large. (2) Absorption of the blood is often slow and the deposition of fibrin on the pleural surfaces is sometimes progressive. This fibrin gradually becomes organized, hampers further pulmonary re-expansion and limits movement of the chest wall. In a

few patients, actual calcification of the thickened pleura or residual effusion occurs.

It was argued in favor of this policy of non-interference that aspiration encouraged recurrence of the hemorrhage and that the damaged lung healed more readily if collapsed.

It is now a general routine to aspirate as much blood as possible about twenty-four hours after the injury (always before the fourth day). The fluid is removed as long as it can be readily withdrawn through a large-bore needle. If the patient complains of a tight feeling in the chest or if considerable force is required to aspirate the blood, air is introduced to relieve the increasing negative pressure. Provided excessively negative intrapleural pressures are avoided, it is improbable that removal of the blood will cause recurrence of the hemorrhage. It has not occurred in our experience. There is very little evidence to support the common thesis that an injured lung heals better if collapsed. There is one objection to partial replacement with air. The air rises to the upper part of the pleural cavity and temporarily prevents the apex of the lung adhering to the parietes. If infection occurs early, an almost total empyema must follow. It is therefore advisable to limit the use of partial air replacement to those cases in which it is not possible to withdraw all the blood without leaving an excessively negative pressure. Grégoire and Courcoux[2] state that, in the absence of infection or gross tissue damage, the blood of a hemothorax does not clot apart from the deposition of a thin fibrin network on the pleural surfaces; this has been our experience. Except for this phenomenon, aspiration would always be difficult and very incomplete.

Infected Hemothorax. The diagnosis of infection rests finally on bacteriological examination (including anaerobic culture) of samples of aspirated fluid. The treatment of infected cases is exactly similar to that of any acute empyema.

So far, the evidence favors a diminution in the incidence of infection and a decrease in the severity of toxemia when infection

does arise as a result of the prophylactic use of the sulfonamide drugs. We have had three cases infected with Clostridium welchii and all have survived. In reference to this latter type of infection, the radiological appearances are often characteristic. When the major portion of the blood has been removed by aspiration, subsequent infection of the residium by gas-forming organisms causes the deposition of fibrin which becomes vacuolated as a result of gas production within its meshes. In a radiogram the appearance is not unlike that of a polycystic lung.

Contralateral Pulmonary Collapse. The cause of this complication remains unproved. Penetrating chest wounds initially make expectoration very painful and it seems almost certain that bronchial obstruction by secretion, or rarely blood, is the explanation of the collapse. It is, therefore, probably justifiable to bronchoscope and aspirate such cases if seen within twenty-four hours of the onset of the collapse. Later than this, removal of secretion is most unlikely to be followed by immediate re-expansion of the collapsed area. Collapse. of the whole or part of the contralateral lung was a very common finding (about 16 per cent) at Casualty Clearing Stations in the last war. We have had only one such case. Re-expansion was slow but complete and bronchography prior to discharge from the hospital showed that bronchiectasis had not complicated the collapse.

Indications for Primary Operation. Primary operation may be indicated to control progressive hemorrhage, convert an open into a closed pneumothorax or prevent sepsis. In addition, most suspected thoraco-abdominal wounds require exploration in order to repair the diaphragm and any damaged abdominal viscus. The exploration should be carried out through the chest in the vast majority of cases in this latter group (Gordon-Taylor[15]).

For those inexperienced in the treatment of penetrating wounds, it is difficult to decide on which patients to operate when

prevention of sepsis is the sole indication. Through-and-through wounds when bony fragments have not been carried into the pleural cavity or lung are unlikely to be followed by sepsis. Retained fragments of shell or bomb casing less than one-half inch in diameter which have entered the chest through an intercostal space infrequently introduce infection and rarely give rise to later trouble. In nine years' work at a military pensioners' hospital after the last war, one of the authors (J. E. H. R.) saw only eighty cases in which retained missiles were giving rise to symptoms. On the other hand large missiles often carry in rib or other bone splinters and foreign material such as clothing; suppuration is then a common sequel.

A great deal of judgment is required to decide which patients to select for primary operation. A surgeon inexperienced in surgery of the chest would be wise to err on the side of conservatism.

Technic of Primary Operations. There are two new practices which merit attention. The introduction of an intercostal self-retaining catheter of the Malacot type prior to the closure of the thoracotomy wound allows the escape of air and effusion and obviates the necessity of postoperative pleural aspiration. It should be in the lower part of the pleural cavity although not actually in the costophrenic sinus as, in the latter position, the diaphragm may rise sufficiently to obstruct the drainage. The site of drainage should never be through the thoracotomy wound or that produced by the missile. The tube is anchored to the chest wall by transfixion with a sterile safety pin which is fixed to the skin with adhesive strapping. It is then connected by rubber tubing to a "water-seal" drainage bottle. The catheter is removed at the end of forty-eight hours and the wound of insertion closed with a single suture inserted at the time of the original operation. Poudrage of the pleural cavity with 10 to 15 Gm. of sulfanilamide before closing the chest is a convenient way of obtaining an adequate early concentration of the drug in

the blood stream and may also give rise to an increased local concentration inhibiting bacterial growth. Much of the drug is, of course, lost through the drainage tube.

Anesthesia. Anesthesia which provides a comparatively small respiratory excursion and does not cause anoxemia or a fall in blood pressure is required. Our patients have been given cyclopropane which fulfills these essentials extremely well but a trained anesthetist is required for its administration. Nosworthy[14] has described with enthusiasm the value of "controlled respiration." It has been employed on our unit when operating on the diaphragm, the immobilization of which is technically a great help; but our experience is limited to such cases. It is difficult to appreciate its advantages when the thoracic wound does not involve the diaphragm. Under most circumstances a mixture of nitrous oxide, oxygen and ether would probably give the most satisfactory results.

Breathing Exercises. This subject is well worn but the absolute necessity of giving all patients with thoracic injuries breathing exercises, shoulder girdle movements and postural training may be emphasized once again. Treatment should start very early during the patient's convalescence; in the absence of infection, gentle exercises and passive movements may begin on the second or third day. Full function will rarely be restored unless such treatment is given. In the case of military patients this means that few patients will be returned to the A1 fitness category. The masseuse's time is more than rewarded by the results obtained for many of the patients leave the hospital with their vital capacity increased to a level above that present before the injury.

These disjointed remarks omitting reference to many major sections of thoracic injury, e.g., wounds of the heart and pericardium, have been prepared in the hope that they may be of some value to those who are anxious to know whether the last two years of warfare have modified the treatment of chest wounds.

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THE PROBLEM OF WOUND SEPSIS IN THORACIC SURGERY*

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MANY of the wounds in thoracic surgery are susceptible to infection because of conditions which are peculiar to such operations. These may be listed as follows:

1. Frequently, the patients are suffering from a chronic disease and some of them may have a lowered resistance to infection.

2. An adequate incision necessitates wide exposure of tissue which may have a low resistance to the organisms which invariably enter every wound. Since the air of every operating room not only may, but usually does have pathogenic bacteria sedimenting from it onto the wound and sterile supplies, the larger wound becomes the more highly contaminated from this source.

3. There is inevitable trauma which is greater than in clean cut incisions in soft parts. This, of course, diminishes the resistance of the tissues to the growth of the bacteria which gain entrance.

4. Hemostasis is unsatisfactory in many cases because of the size of the wound, the many small bleeding points, the relative inaccessibility of certain bleeders and the possibility of bleeding coming on following closure of a "dry wound" as a result of uncontrollable motion associated with respiratory movements.

5. The dead space left following many operations cannot be obliterated. This is particularly true after the first-stage thoracoplasty with apicolysis or after a pneumonectomy.

6. The wound cannot be put at rest, as is best for healing, because of the respiratory movement and continuous changes in the intrathoracic pressure in the presence of a mobilized chest wall.

The wounds with which we have to deal may be divided into the following groups:

1. *Traumatic Wounds.* (In which contamination exists when the patient comes under treatment.) In these wounds which enter the pleural cavity careful first aid is of the utmost importance. The small, clean-cut wound should be closed after careful cleansing. The ragged wound with extensive trauma to tissues, and the possibility of the presence of clothing, wadding or any foreign material other than smooth metal, must be carefully explored as soon as the condition of the patient will permit it. It should be thoroughly washed out with a nonirritating solution and all foreign material, blood clot and severely traumatized tissue should be removed. Bleeding must be carefully controlled, the least irritating sutures and ligatures should be used to close the wound without drainage and with the minimal trauma to tissue and least constriction of blood supply.

At the present stage of our knowledge of sulfonamides, a suitable one of these should be sprinkled in the wound to inhibit bacterial growth. At times it may be necessary to shift a flap of soft parts to close a large defect opening into the pleural cavity, but the pleurae must be closed by some method if the condition of the patient will permit it.

If infection occurs, the empyema should be treated as any other empyema and the chest wall wound should receive adequate drainage but with support to limit the separation and if possible avoid a sucking wound, as is done in the case of the wound following pneumonectomy, as described later in this paper.

The low grade infection in a pleural cavity filled with organizing blood clot demands special consideration. In these there may be multiloculated pockets which make drainage unsatisfactory while the fibrin and organizing hematoma prevent expansion of the lung and apposition of the pleural surfaces. While our experience with these has been limited, it seems to us that where this condition exists the thorax should be opened sufficiently to give adequate exposure, all the fibrin and organizing hematoma should be evacuated and the resulting cavity should be treated by irrigation until there is a clean granulating wound which can then be closed by the suitable application of suction.

2. *Large Clean Primary Incisions.* (Such as first-stage thoracoplasties or thoracotomies.) In these clean wounds contamination from sources other than the air we feel have been largely brought under control in the well run operating room. The wound itself, left by a well trained surgeon in the best possible condition for healing, can handle the few bacteria that gain entrance, if the relatively high contamination from the air during periods of widespread respiratory tract infection is brought under control. Infections in these wounds should be rare and seldom severe.

3. *Reopened wounds* such as second and subsequent stage thoracoplasties are susceptible to infection from at least two sources not present in the primary incision:

(a) The first of these is from the few organisms which may have gained entrance to the preceding wound, found a harbor about catgut sutures or in a pocket of fluid in a dead space, multiplied there but not to the extent of causing sufficient local or general reaction to be diagnosed as an infection, and are present in far greater numbers to be distributed through the tissues freshly exposed at the subsequent operation.

(b) The second of these sources is from organisms normally present on the skin which may have grown along the skin sutures of the preceding stage to form clusters of organisms which may be distributed through the reopened wound. When the reaction about the sutures is sufficiently great we have the well known stitch abscess, but there must be a less extensive growth of organisms about many other sutures.

Whatever the explanation, when the air as a source of wound contamination is eliminated, the reopened wound is more susceptible to mild or moderate infection than the primary incision.[12] On the other hand, in our experience when the air as a source of contamination is not eliminated the reopened wound is less susceptible to severe infections than the primary incision. Our explanation of this is that the patient at the time of the second operation has developed some immunity as a reaction to the contaminants which gained access at the previous exposure.

In our experience infections in reopened wounds, protected from air contaminants, have been mild, localized and in the subcutaneous fat or a pocket of fluid in a dead space.[12]

4. Certain wounds are potentially infected from the nature of the disease and the operation. Examples are those made for a lobectomy or pneumonectomy. If every precaution is taken to limit soiling when the bronchus is divided and the stump of the bronchus is buried beneath tissue with an adequate blood supply to prevent it from reopening, many of the cases will not develop an infection. The pleural cavity may or may not be drained, depending on the judgment of the operator as to the probability of infection. If infection occurs in the undrained pleural cavity, it is easy to drain through a tube inserted by the trocar and cannula technic. Where there is a large dead space which must be collapsed, as following a pneumonectomy, it is important to insert the tube so as not to interfere with an extrapleural paravertebral thoracoplasty, which then can be performed in a sterile field. If there is no bronchial fistula, the cavity can be drained, irrigated and partially collapsed

by suction; or if there is a bronchial fistula, continuous aspiration can be applied through a tube inserted well anteriorly. In either case treatment can be carried on indefinitely without leakage of pus around the drainage tube. The advantages of collapsing the infected pleural space down to a small residual cavity by means of operations performed in an aseptic field are too great to need further comment. The small residual cavity can be further treated by closed drainage, open drainage or by unroofing as the individual case may demand.

5. Wounds grossly contaminated by highly pathogenic aerobic, anaerobic or mixtures of organisms as follow drainage of a lung abscess, demand special consideration, since the secondary dissecting infections in the cleavage planes of the chest may present a greater threat to the life of the patient than the original disease. At one time it was our opinion that drainage of every lung abscess should be delayed until the chest wall incision down to the pleura had been packed sufficiently long to allow sealing off of the cleavage planes and the development of granulations over the incised tissues. However, with the preoperative and postoperative use of arsenicals intravenously to inhibit the fusospirochetal organisms, with the wound edges protected from the more gross contamination at the time of and following operation, with the wound left wide open for drainage and aeration, and more recently with the aid of the sulfonamides, we can in most instances, in which the pleural cavity over the abscess has been obliterated by adhesions, drain these abscesses in one stage.

The problem of wound sepsis logically falls into two divisions. The first of these is prophylactic or the avoidance of infection, while the second is concerned with the treatment of the infection once it has been established. In the case of clean wounds we should develop a technic which will eliminate most of the latter division so that an infected wound will become a

rarity. This statement is made without reservation since such a condition exists in the operating rooms of the Duke Hospital today and can be easily duplicated elsewhere.[12]

Every phase of surgical technic has its bearing on whether or not the wound will develop an infection. Theoretically, if every bacterium could be kept out of the wound at the time of and following operation, we could not have an infection. Under these conditions we still could have poor healing as a result of traumatized tissues, collections of blood or serum, irritating sutures, drains, packs, etc. However, if anyone operates using such technic, it is all the more imperative that the number of viable bacteria entering the wound be kept to the minimum. Since some bacteria enter every wound, a goal of complete asepsis is unattainable and this makes it all the more important that we leave the wound in the condition best for healing in the presence of the lowest contamination that can be obtained. The ideal wound should be made with minimal trauma and closed with an accurate reapproximation of normal structures by means of non-irritating sutures, which do not strangulate tissues or interfere with their blood supply. There should be no dead space, no bleeding into the wound or tissues and no drains or packs should be inserted. The tissues should be placed at complete immobility in such a position as is conducive to good blood supply and good blood and lymph drainage. Since each of these more or less ideal conditions is unattainable, we must strive for the nearest possible approach to them.

The patient should be kept in the best possible condition before, during and following operation. His disease should be brought under the maximum control by adequate hygienic measures; his general nutrition, vitamin, fluid, and salt balance should be maintained at the optimum level. While rest may be very important in the treatment of tuberculosis, complete bed rest with its resultant atrophy of muscles, including the myocardium, and resultant

circulatory instability may be poor preparation for an operation.

Following operation the patient should

FIG. 1. (No. 77533.) A tumor of the left main bronchus of four years' duration caused complete obstruction with multiple abscesses thoroughout the left lung. The lung was removed on January 2, 1937.

receive rest, but not to the extent of avoiding frequent changes of position to improve the circulation, and to allow drainage of fluids from the dependent parts, particularly in the lungs and in the operative region. The local wound should be immobilized, but not to the extent of embarrassing respirations by tight bandages or keeping the wound dependent at all times in order to let the weight of the patient compress and splint it.

Too frequent dressing of the clean wound results in needless inconvenience, fatigue and pain to the patient, and opens the wound unnecessarily to the dangers of infection. On the other hand, particularly during hot weather, the dressings on the fresh wound may become saturated with serum or a mixture of serum and perspiration; and if these are not removed, maceration of the epidermis along the suture line may result, particularly if the patient is permitted to lie on the operative side. Dressings performed with reasonable frequency and washing of the skin with

alcohol may diminish the skin contaminants, avoid the development of stitch abscesses and result in better healing.

Even though, as stated above, we cannot prevent the entrance of every bacterium into a wound we should set this as the goal toward which we strive and exercise every precaution which may aid in its attainment. Among these precautions are the following:

The usually accepted aseptic technic with the sterilization of all instruments and supplies, careful skin preparation, isolation of the wound from the skin as soon as the incision is made, the covering of the carefully prepared hands of the operating team with sterile gloves, etc., etc., should be scrupulously and intelligently followed. This means that "aseptic technic" is not to be carried out by rote because it is the accepted thing to do but that every procedure is performed with a definite purpose in mind. These are determined by cultural checks on each step of the operative procedure, the results of which must be familiar to every member of the operating team.

An additional warning should be given in regard to the sterility of the prepared skin of both the patient and the personnel. Scrubbing with soap and water does not render the surface of the skin free of bacteria, but when this is supplemented by adequate chemical treatment, including the use of 70 per cent alcohol on the hands, the surface of the skin when cultured is relatively free of viable bacteria. On the other hand, at the end of the operation, particularly in hot weather when perspiration enters the picture, many of the skin contaminants may be on the surface of the hands of the operating team or skin of the patient at the operative site. This makes it imperative that every precaution be taken to avoid puncturing the glove, and that nothing touching the skin be permitted to come in contact with the patient's wound. If hemostatic forceps are to be left on the wound, they should be protected from the underlying skin

with a sterile towel and the wound itself should be protected by a second towel which overlaps the skin edges and covers

Contamination of the clean wound, and exposed sterile supplies by organisms given off from the noses and throats of the occupants

FIG. 2. (No. 77533.) The cavity following removal of the lung shown in Figure 1 developed a mixed infection including anaerobic organisms. A drainage tube was inserted on January 9, 1937, and the cavity was treated by closed drainage, tidal irrigation and suction for thirty days. Note the diminution in the size of the cavity brought about by elevation of the diaphragm, shift of the mediastinum and partial collapse of the chest wall.

FIG. 3. (No. 77533.) A first-stage extrapleural paravertebral thoracoplasty with removal of parts of five ribs was performed on February 8, 1937, thirty-seven days after the pneumonectomy and thirty days after the institution of tidal irrigation and suction. In such patients a larger number of ribs can be removed without serious disturbance to the respiratory mechanism since the patient has already become adjusted to the use of only one lung and the mediastinum can be stabilized by suction within the cavity to pull the walls of the cavity into apposition.

the clamps. The clamps can then be removed at the end of the operation without contaminating the gloved hand, or ligatures can be applied without contaminating the ligature as it slides along the clamp. The knife used for the skin incision should of course be discarded as soon as it has divided through the contaminated glands in the skin, and this part of the wound should be covered. These covers should not be removed until the operation has proceeded to the closure of all the underlying layers of tissue. They should then be removed, all exposed skin treated with a suitable antiseptic and recovered up to the edge of the incision with sterile drapes before proceeding with the closure or otherwise touching the skin.

of the operating room, transported by way of the air, and sedimenting on the sterile field, constitute in our opinion the greatest danger of infection in these large wounds in the well run operating room of today.[7] We have long made a useful gesture toward the control of this danger by the conventional mask worn over the mouth and, in more recent years, almost universally over the nose. The importance of this masking in cutting down massive contamination from rapidly sedimenting large droplets cannot be emphasized too strongly. On the other hand, the generally accepted mask should not give one a false sense of security since it will not prevent a rapidly

increasing contamination of the air with small droplets or droplet nuclei which are the bacteria left after the liquid has

FIG. 4. (No. 77533.) On February 23, 1937, fifteen days after the first-stage thoracoplasty, the remaining six ribs were resected and the empyema cavity was treated by suction and irrigation for the next forty-two days. On April 6, 1937, the small residual cavity demonstrated here by lipiodol injection was collapsed by removing the ribs and thickened pleura overlying it and the soft parts were allowed to fall in. The patient was discharged with the wound almost healed sixteen days following the latter operation.

evaporated, as has been emphasized in recent publications by Wells. Sneezing, coughing and talking should be prohibited or reduced to the minimum. The potential danger from the presence of a nose and throat carrier of highly pathogenic and virulent bacteria in the operating room is in our opinion immeasurably greater than is generally accepted by most surgeons today. Elimination of every transient carrier is difficult but the persistent carrier of highly pathogenic beta hemolytic streptococci or hemolytic yellow staphylococci should not be allowed in the operating room.

Air contamination can be kept down by limiting the number of occupants during, and the duration of occupancy before, these operations. It can also be reduced

or held down by an efficient ventilating system which supplies large quantities of clean air (free of pathogenic bacteria)

FIG. 5. (No. 77533.) X-ray of the chest after the right pleural cavity had been obliterated as described under Figures 1 through 4.

to the operating room.[2] The reserve sterile supplies can be protected partially by a mechanical sterile canopy which may reduce the number of colonies of viable sedimenting bacteria reaching the supplies by 50 or more per cent or by a canopy of bactericidal radiation which will kill all bacteria falling in an exposed position within one to two minutes. The two can be combined by placing the radiation unit beneath the mechanical canopy. The mechanical canopy is impractical for the operative field but a radiation canopy has proved to be quite effective and is very practical.[1,12]

Daily cultures of the air will demonstrate periods of rising or falling air contamination and the type of bacteria present, thus aiding in anticipating the periods of greatest danger to large clean wounds.[3,7]

While these measures are all important, with the exception of radiation, they are not sufficient to give a reasonable guarantee against infection from air-borne contaminants. Killing the bacteria in the air seems to be the only feasible method of curbing this danger, and this can be done with ultraviolet radiation (2537 Å) which has a high bactericidal and low erythermal or

burning effect. The effectiveness of this addition to aseptic technic is demonstrated by the following facts:

1. Culture plates of blood agar inoculated with pathogenic bacteria can be sterilized at the operative site with an exposure of two to five minutes[9] to an intensity of radiation which will not produce evident damage to the tissues[8] or the suitably protected personnel during the course of even prolonged operations.[11,12]

2. Sedimenting viable bacteria at the operative site can be reduced by 95 to 99+ per cent by this same intensity of radiation.[1]

3. The few bacteria which survive such an exposure seem to be attenuated.

4. Unexplained infections in primary thoracoplasty incisions in the Duke Hospital were reduced by over 99 per cent.[12]

5. Infections in reopened thoracoplasty wounds in the Duke Hospital were reduced by 75 per cent.[12]

6. Deaths from unexplained infections in large wounds (thoracoplasty, craniotomy, arthoplasty, etc.) in the Duke Hospital were reduced from 1.07 to 0.00 per cent.[12]

7. Unexplained severe infections in thoracoplasty incisions (all stages) at the State Sanatorium at Sanatorium, North Carolina, were reduced from 22.7 to 1.09 per cent* simultaneously with the installation of bactericidal radiation.[12] The only infection they had in the ninety-two thoracoplasty stages since the installation of radiation was in a wound reopened for the second stage. Such a wound, of course, has sources of infection other than the air which are not present in the primary incision.

The number of bacteria in a wound at the time of closure can be reduced by washing. This is strongly advocated by some but in our hands before installation of radiation it was at the best only partly satisfactory.

In recent years, the sulfonamides are being widely used in wounds that are

* Monroe, Clement R. Personal communication, 1941.

potentially contaminated. Naturally, they have been tried in thoracoplasty wounds but we have not used them since infections in such wounds in our operating rooms had already been practically eliminated by ultraviolet radiation. According to personal communications favorable results have been obtained by those who have used them. Undoubtedly, published results will soon appear in the literature.

Every thoracoplasty wound because of its character and size is potentially infected, and the infection rate is higher than the average surgical wound made under similar conditions. The decision as to whether or not to use the sulfonamides must be left to the judgment of the individual operator, since this decision must in the last analysis be based on his previous experience and his resultant judgment as to the possibility of infection developing in any individual wound. Where there has been a source of gross contamination, whether from a torn glove with loss of perspiration in the wound, from the air during a period of high contamination with highly pathogenic bacteria or from any other source, such a drug should be used. In view of the additional sources of contamination of reopened wounds, it is possible that one of the sulfonamides should be used even where there has been no break in technic and where the air as a source of contamination has been eliminated. This entire problem will be much clarified with additional years of experience.

Treatment of the infected thoracoplasty wound does not differ from similar infections in other wounds except insofar as the wounds differ. Naturally, infection in such a wound may be extensive and serious. They are treated by adequate drainage, chemotherapy, multiple transfusions if indicated, specific serum if such is available, and general supportive measures.

TREATMENT OF THE CAVITY FOLLOWING LOBECTOMY AND PNEUMONECTOMY

These wounds are potentially infected, but if infection can be avoided by careful

handling of the bronchus and meticulous technic, the operation is simplified, the convalescence is shortened, the safety of

beneath a flap of tissue with an adequate blood supply where this is possible. The avoidance of a bronchial fistula is impera-
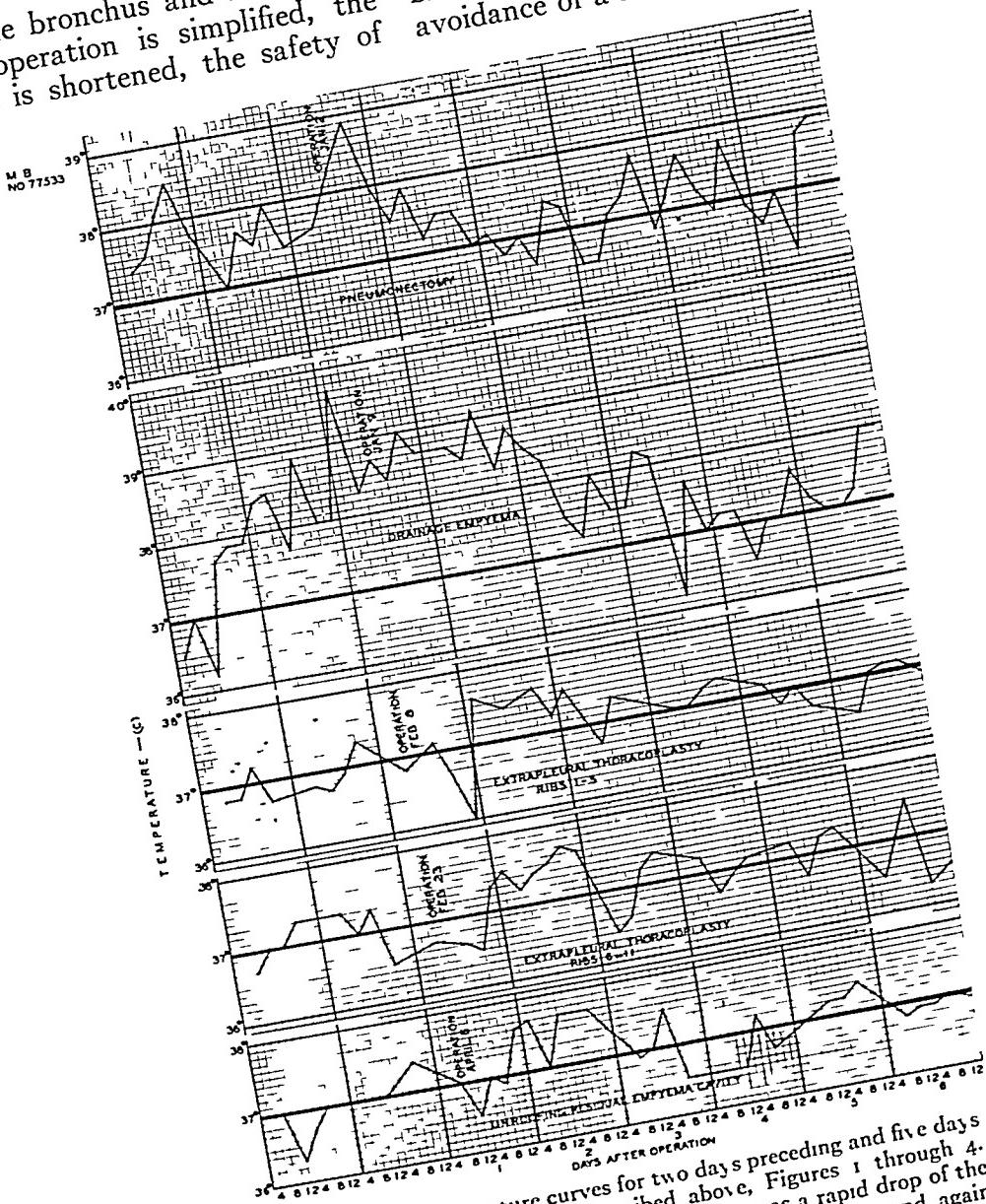
FIG. 6. (No. 77533.) Temperature curves for two days preceding and five days following each of the operations described above, Figures 1 through 4. Particular attention is called to the fact that there was a rapid drop of the temperature elevation following removal of the infected lung and again following drainage of the empyema cavity. Throughout the remainder of the patient's period of hospitalization with three operations (first- and second-stage extrapleural thoracoplasty, and unroofing of residual empyema cavity) there was no elevation of temperature on these charts or in the intervals not shown here above 37.7°C. (99.9°F.) and after each of these operations the temperature was down to normal within forty-eight hours.

the operation is increased and postoperative deformity is reduced. Every part of the wound should be carefully protected when the bronchus is cut across, the stump should be carbolized, closed and buried

tive when an unobliterated dead space is to be left, and simplifies the convalescence in those cases in which infection occurs and obliteration of the dead space is necessary for healing.

If there is a reasonable chance that infection can be avoided, the wound may be closed without drainage, and one of the sulfonamides may or may not be left in the wound according to the judgment of the operator. The condition of the patient, however, must be followed closely for evidence of infection or increasing intrathoracic pressure. If either is suspected, a needle should be inserted to determine the exact condition present. and if there is increased tension this can be relieved. When infection develops in the cavity, closed drainage and irrigation should be instituted. For the cavity following a lobectomy, the tube should be inserted in the dependent part of the cavity in the posterior axillary line, since this will give dependent drainage and at the same time permit the patient to lie flat on the back in comfort and without obstructing the drainage tube. If a bronchial fistula develops, suction can be maintained until the cavity is obliterated to a fistulous tract which will close when the tube is removed.

In the case of intrapleural infection following a pneumonectomy performed through an anterior incision, it is our policy to insert the tube for closed drainage through the anterior chest wall in the lower part of the cavity so as not to interfere with an extrapleural paravertebral thoracoplasty to be performed subsequently in an aseptic field. The tube can be inserted to such a depth as to irrigate from the dependent part of the cavity; and if there is a bronchial fistula, the pus can be aspirated from the most dependent part of the cavity so as to keep it empty. Under the latter condition with a large fistula negative pressure within the cavity may not be obtainable, and if the tube should be inserted into the pleural cavity below the fluid level, pus may find its way by gravity along the sinus tract about the tube. However, with the tube inserted through the anterior chest wall above the fluid level there can be no leakage of fluid along this sinus tract. Subsequent treat-

ment may then be divided into the following stages:

1. Continuous irrigation either with an

Fig. 7. (No. 77533.) Photograph showing beneath the breast the skin incision for the pneumonectomy. The breast was reflected upward and the chest entered through the third interspace. In the midaxillary line can be seen the scar from the incision made for unroofing the residual cavity after the pleural space had been collapsed to a large extent by suction and the extrapleural thoracoplasty.

antiseptic solution or a nonirritating solution is carried on to keep the infection under control and to limit absorption. (Figs. 1, 2 and 6.) In the presence of a bronchial fistula we must be content with continuous suction and aspiration of the pus from the dependent part of the cavity along with intermittent washing out of the cavity with nonirritating fluid in quantities insufficient to flood the open bronchus. Under either condition free drainage can be obtained with a drop in the temperature reaction. (Fig. 6.) This should be the principal treatment until the acute infection has subsided. If there is infection in the chest wall incision, it may drain into the pleural cavity or to the surface, or both. Occasionally, such an incision may break down to give a sucking wound; and if this occurs, drainage can be allowed and, in the absence of a bronchial fistula, suction on the cavity maintained by covering the

wound with a sheet of thin rubber. Dental dam serves this purpose well. The wound should be supported to limit the amount of

During a pneumonectomy, every effort should be made to avoid a bronchial fistula since its presence makes the applica-

FIG. 8. (No. 77533.) Photograph showing the scars from the extrapleural thoracoplasty performed in two stages without infection (see Fig. 6) by the usual aseptic technic in a field of bactericidal radiation, while the infected pleural cavity was being drained by closed tidal irrigation. In the meantime, the cavity was being obliterated by pulling the surfaces into apposition by suction. See Figure 6 for the temperature reaction following these operations.

separation. In our experience infection with breaking down of the chest wall incision is rare as compared to infection within the pleural cavity.

2. After the infection has been brought under control suction is applied to obliterate the cavity. (Fig. 2.) Following a lobectomy, this is accomplished by further expansion of the remaining lung, elevation of the diaphragm, shift of the mediastinum and partial collapse of the chest wall with a narrowing of the intercostal spaces and a greater obliquity of the ribs. Following a pneumonectomy, there is no remaining lung on the operative side to expand but the other factors all come into play with a shift of the mediastinum and increased expansion of the opposite lung. (Fig. 2.)

tion of continuous and constant suction impossible, thus losing the great advantage of suction in obliterating the cavity.

3. While free drainage is provided by continuous irrigation and suction through a tube inserted anteriorly and leakage of pus about the tube is insured against by negative pressure within the thorax, or the location of the opening in the chest wall above the fluid level, the remaining cavity resulting from a pneumonectomy is obliterated by sucking the clean granulating surfaces into apposition as the chest wall is mobilized by an extrapleural, paravertebral thoracoplasty performed in suitable stages. (Figs. 3-8.)

4. The small residual cavity may be treated by open drainage or by complete

unroofing, with the soft parts of the chest wall falling into the cavity. (Figs. 4–7.)

CONCLUSIONS

1. The problem of wound sepsis in thoracic surgery can be largely solved for the clean primary incisions by the use of the most carefully controlled *atraumatic* technic along with the generally accepted *aseptic* technic and with the *addition of suitable measures* to *control wound contamination* by *air-borne pathogenic bacteria*.

2. If wound infection develops in the thoracoplasty incision, it is treated as any other wound infection except insofar as the treatment is influenced by the chronic illness of the patient, the size of the wound and the resultant seriousness of the condition.

3. Contaminated and potentially infected wounds should be treated as the clean wound, but with every additional precaution to avoid spreading the contamination and with one of the sulfonamides in the wound and in the blood to inhibit bacterial growth.

4. In the intrapleural operations every effort should be made to avoid infection and if this develops it should be drained through a stab wound and every precaution taken to avoid a breaking down of the larger incision.

5. In lobectomies and particularly in pneumonectomies every precaution should be taken to avoid a bronchial fistula. The end of the divided and closed bronchus should be covered if possible with a flap of tissue with an adequate blood supply which will grow into position before the ligatures and sutures cut through.

6. The pleural cavity infected following a lobectomy can usually be obliterated by suction alone or with the addition of open drainage of the sinus tract or the small residual cavity.

7. A fistula into an open bronchus will close if the cavity can be obliterated to a long fistulous tract.

8. The infected hemothorax following a pneumonectomy can be treated and closed by continuous irrigation through a tube inserted anteriorly out of the field of an extrapleural paravertebral thoracoplasty to control the infection, by suction to obliterate the dead space as the chest wall is mobilized by an extrapleural paravertebral thoracoplasty performed in suitable stages in an aseptic field, and by open drainage or unroofing of the small residual cavity.

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DIAPHRAGMATIC HERNIA

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ALTHOUGH many articles have been written on the subject of diaphragmatic hernia, it continues to be of interest. This interest extends alike to the general practitioner and to many of the specialists. Symptoms resulting from the condition may take the patient to the internist, gastroenterologist, cardiologist, phthisiologist, general or thoracic surgeon, pediatrician or roentgenologist. All must, therefore, be familiar with its symptomatology, its various types and the methods of treatment for each. Many of the small hiatus herniae are in all probability only incidental findings of no clinical importance and the physician must judge which are to be subjected to surgical treatment, which may be treated by medical measures and which may be disregarded. The experience of recent years has shown that the patient with a congenital hernia should be treated surgically, and authorities[1,2] are now agreed that the repair should be carried out as soon as possible.

The condition of diaphragmatic hernia is not rare and the roentgenologist in a general hospital of 300 or more beds may easily see fifteen cases each year. A recent report from the New York Hospital[3] shows an incidence of 2 per cent of diaphragmatic herniae in 4,400 consecutive examinations of the gastrointestinal tract. The incidence of the various types of herniae depends somewhat on the age and type of patient making up the hospital population. With an active pediatric service there will be an appreciable number of the interestingly variable group of congenital herniae, whereas in the hospital which treats large numbers of patients in the cancer age there is a relatively high incidence of hiatus herniae. With an active service of traumatic surgery in an industrial community the number of traumatic herniae may be large. Age, however, is not a trustworthy guide in the differential diagnosis and an occasional patient may live to a ripe, old age with a congenital hernia and without significant symptoms referable to the respiratory or intestinal tracts.

CLASSIFICATION

Diaphragmatic herniae and the associated abnormalities of the intestinal tract and diaphragm may be conveniently classified according to the accompanying schema. It should be noted that the complete and partial thoracic stomachs are not properly referred to as herniae since the term, "hernia," requires that a once normally placed organ be shifted so that it protrudes through the wall of the cavity normally containing it. The thoracic stomach was formed above the diaphragm and has remained permanently in that position because of the abnormally short esophagus.

The classification includes no indication of whether the hernia is true or false. The presence or absence of a serous sac is of some interest but knowledge concerning this feature can almost never be obtained with certainty prior to operation.

1. Thoracic Stomach
   Entire stomach above the diaphragm.
   Esophagus very short, ending at about the level of the fourth thoracic vertebra.
2. Short Esophagus with Partial Thoracic Stomach
   Part of stomach permanently above the diaphragm.
   Esophagus ends at level of seventh or eighth thoracic vertebra.
3. Hiatus Hernia
   All or part of stomach herniated through hiatus esophageus.
   Esophagus of normal length.

4. Congenital Hernia
    Most common through the foramen of Bochdalek, but may occur through defects elsewhere in the diaphragm.
    Large and small bowel usually included; other organs frequently.

5. Traumatic Hernia
    May occur through any part of diaphragm.
    Organs involved similar to those of congenital type.

6. Eventration of Diaphragm
    Diaphragm high but intact.

7. Congenital Absence of Diaphragm

ANATOMY

The development and structure of the diaphragm has been described in considerable detail in a recent paper by Harrington[1] but may be reviewed briefly here. The incompletely formed diaphragm may be identified in the embryo of about 7 mm. length and while the embryo grows to about 17 mm. in length this incomplete diaphragm moves caudally at a rate somewhat greater than the rate of elongation of the upper part of the enteric tube. As a result of this difference in rate of growth of the two structures the stomach is for a time partly above the diaphragm. The elongation of the esophagus begins when the embryo is about 10 to 12 mm. in length and the stomach is normally below the diaphragm when the latter structure is completely formed at the 20 mm. stage. Closure of the right leaf of the diaphragm is complete prior to closure of the left, thus accounting in part for the higher incidence of congenital herniae on the left side.

The muscle fibers make their first appearance in the diaphragm only after its structure is otherwise complete. These muscle fibers do not make up a continuous band around the periphery of the organ, but are plainly divided into three groups according to their sites of origin. The pars sternalis is a narrow band arising from the posterior aspect of the xiphoid process, and the line of separation between this band and the much larger pars costalis is usually clearly seen even in the adult. This line of separation marks the embryologic foramen of Morgagni and through it passes the superior epigastric artery. (a branch of the internal mammary artery). The pars costalis arises from the costal cartilages of the six lower ribs. The pars lumbalis arises posteriorly from the crura and from the medial and lateral lumbocostal arches. The crura arise from the anterior and lateral aspects of the first three lumbar vertebrae. The medial lumbocostal arch is a fibrous band which extends from the body of the second lumbar vertebra to the transverse process of the first and bridges the psoas muscle. The lateral lumbocostal arch extends from the transverse process of the first lumbar vertebra to the twelfth rib and bridges the quadratus lumborum muscle. The line of separation between the pars lumbalis and the pars costalis is the site of the embryologic pleuroperitoneal hiatus or foramen of Bochdalek.

These three segments of musculature are frequently not solidly fused even in the adult, and the narrow zones which may separate the segments are made up only of a thin layer of connective tissue, covered above and below by pleura and peritoneum. The zones of connective tissue are much less resistant to pressure than are the adjoining segments of muscle and hence are frequently the sites of herniae.

Of the several openings in the diaphragm through which structures normally pass, that of the aorta is most posterior and is at the level of the first lumbar vertebra. This opening is not properly within the diaphragm but its anterior and lateral boundaries are formed by the crura as they extend forward from their points of origin on the spine. The thoracic duct and the azygos vein pass through the opening closely adjacent to the aorta. The opening is well bounded by dense fibrous tissue and is not a site of hernia formation. The esophageal opening is somewhat more anterior and is at the level of the tenth thoracic vertebra. Besides the esophagus it transmits also the esophageal vessels and the vagus nerves. It is entirely within the

muscular portion of the diaphragm, being surrounded by the decussating bundles of the crura before they spread out into the central tendon. There is considerable variation in the size of this opening and the space not occupied by the structures passing through it is filled by loose areolar tissue. The muscle fibers of the crura do not attach to the esophagus and some mobility of the structures is thus permitted during respiration and deglutition. It seems quite probable that the hiatus herniae so frequently seen in older people are the result of relaxation of this connective tissue. The opening for the vena cava is situated still farther anteriorly and at a still higher level, being opposite the eighth thoracic disc. It is within the central tendon of the diaphragm just to the right of the midline and is well protected by the liver.

THORACIC STOMACH

In cases of true thoracic stomach all or nearly all of the stomach is above the diaphragm, being held there as a result of extreme shortness of the esophagus. The group of such cases is very small but the term, "thoracic stomach," should be reserved for this small group and should not be used for the large number of hiatus herniae in which a relatively large portion of the stomach may be within the chest but in which the esophagus is of normal length. The true thoracic stomach is the result of an embryologic fault in which the esophagus is very short and terminates usually at or near the level of the aortic arch. The term, "hernia," may not properly be applied to this small group of cases since the stomach was not at any time in its normal position in the abdominal cavity. The classic case to which the name was originally given is that of Bailey.[4] It is of interest that his patient lived to be seventy-seven years of age and apparently had no significant symptoms referable to his gastrointestinal tract.

In the cases so far reported the stomach has been invested in a serous sac which communicated with the peritoneal cavity,

but in no case has any other abdominal organ been involved.

SHORT ESOPHAGUS WITH PARTIAL THORACIC STOMACH

There is a second and somewhat larger group of cases in which there is also shortening of the esophagus, and in which a part of the stomach must, therefore, remain within the thorax at all times. This second group, however, differs from the preceding group in that the degree of shortening of the esophagus is not so marked, and as a result only about one-third to one-half of the stomach lies above the diaphragm. The group is of considerable interest and appears to be clearly differentiated from the small group of thoracic stomachs. The very short esophagus associated with the true thoracic stomach terminates at about the level of the fourth thoracic vertebra, whereas in this second group the termination is almost always opposite the seventh or eighth thoracic vertebra. Kelly[5,6] has been especially interested in the problem of the short esophagus and has called attention to the constancy of the level at which it enters the stomach. Each of the four cases seen by the author has shown the esophagogastric junction to be opposite the seventh or eighth thoracic vertebra, and in each there was definite constriction at the junction.

In the earlier studies of this group of cases the shortening of the esophagus was thought to be the result of anomalous development, but more recently it has been suggested[6,7] that the shortening might be either congenital or acquired. Many of the cases show definite constriction at the junction of the esophagus and stomach and in some this constriction has extended for a distance of 1 to 2 cm. In a few, actual ulceration of the mucosa has been noted at the junction.[8,9,10] The constriction either with or without actual ulceration at the time of study, has suggested that the shortening of the esophagus might be the result of an inflammatory process. In proof of this theory is the case reported by Kelly[6] in

which a definite esophagitis was found at autopsy.

It is of considerable interest that almost

against the lesion. If the narrowing be of this degree and if the patient be maintained in the erect position, the thin trickle of

FIG. 1. Woman, seventy-five years of age. Had had difficulty in swallowing for about twenty-five years. First seen by laryngologist about fifteen years before and had been dilated repeatedly since for presumed esophageal stricture. Treatment afforded relief but it had not been appreciated that the stomach lay immediately beyond the stricture. Note that the narrowed esophagus enters the stomach at its apex.

all of the early work in this group of cases was among patients who were thought to have strictures of the esophagus. This was true of the last two patients seen by the author. Both were elderly women who had been followed as cases of stricture for some years and had had repeated dilatation of the lower esophagus with relief. That a part of the stomach lay immediately beyond the stricture and above the diaphragm had not been known, due to the fact that barium had never been given with the patient in the supine or Trendelenburg position.

Narrowing of the esophagus, when first seen by the roentgenologist, is frequently of such a degree that only a thin trickle of barium emulsion will pass through it. This may be true even when the patient stands erect and when the hydrostatic pressure of a considerable column of fluid is exerted

barium will not completely fill that portion of the tube immediately beyond the lesion, but will instead gravitate to the most dependent portion of the stomach. It is, therefore, necessary to place the patient in the Trendelenburg position so that the barium may collect distal to the lesion and demonstrate the full caliber of the organ which lies there. A complete or partial thoracic stomach with a short esophagus would thus be readily differentiated from a simple stricture of the esophagus.

It should be noted that in cases of short esophagus the esophagus enters the intra-thoracic portion of the stomach at its apex and that the cardiac end of the stomach tends to be cone-shaped. This is in contrast to cases of hiatus hernia in which the esophagus enters the stomach from one side (usually the right posterior aspect) and

the fundus retains its usual rounded contour.

The symptomatology of the group of

short esophagus is due to the constriction which is so often present at the esophago-gastric junction.

Fig. 2. Conventional Bucky film of a hiatus hernia of the "acquired" or "sliding" type. Note that the esophagus enters the stomach from the side in the same manner that it does normally when the stomach lies below the diaphragm.

cases of partial thoracic stomach with short esophagus is somewhat different from that of the large group of cases of hernia through the hiatus esophageus, in which the esophagus is of normal length. The patient with the short esophageus is most apt to complain of difficulty in swallowing solid foods. As is noted below, the patient with a simple hiatus hernia is more apt to complain of a feeling of fullness after eating, of sour eructations, or of pain in the left chest simulating angina pectoris. The patient with hiatus hernia almost never complains of difficulty in swallowing. The difficulty in swallowing associated with the case of

Treatment of these patients, therefore, consists in dilatation of the constricted area, and such treatment usually brings about a satisfactory result. The dilatation may be combined with a modified ulcer régime directed against the inflammatory process and the tendency to ulceration. Harrington[1] has operated upon eleven patients in whom the roentgenologic diagnosis was partial thoracic stomach and short esophagus, but at operation found that the esophagus was actually short in only four. He states that in all but one patient he was able to bring the stomach below the diaphragm after separation of

the tissues around the hiatus and interruption of the left phrenic nerve. Truesdale[11] has reported one such case in which he was unable to maintain the position of the stomach below the diaphragm. This case was also referred to in a previous paper by the author,[12] whose opinion is that no attempt should be made to bring the stomach below the diaphragm in these patients. The belief that surgical repair should not be attempted in these cases makes the differentiation of this group from the hiatus group of paramount importance, since the hiatus hernia may be repaired and all symptoms referable to it relieved.

HIATUS HERNIA

Herniae through the hiatus esophageus constitute the largest group of diaphragmatic herniae. They are most frequent in persons beyond forty years of age and are more common in women than in men. The group may be subdivided depending on whether the esophagus enters the stomach above or below the diaphragm. In either case the esophagus is of normal length. In the "para-esophageal" type the lower end of the esophagus remains fixed within the hiatus and the cardiac end of the stomach herniates upward beside it. In the so-called "acquired" type, which is seen most commonly in the advanced age group, the lower end of the esophagus is not fixed but withdraws into the posterior mediastinum together with a portion of the stomach. Either of these two types may slide freely through the hiatus with change in position of the patient, or may be incarcerated. In both types the fundus of the stomach retains its normally rounded contour, and in both, the cardiac orifice is on the side rather than at the apex, as was the case with the shortened esophagus.

The hiatus hernia may vary in size from those which involve only a very small portion of the fundus of the stomach to those which involve the entire stomach. In the latter case the transverse colon may also be included as a result of traction by the gastrocolic omentum. The author has per-

sonally seen one patient (Case 4[12]) in which the fundus of the stomach lay beneath the left diaphragm and the antrum above it.

Fig. 3. Spot film of hiatus hernia.

Dr. George W. Holmes has demonstrated films of an identical case seen at the Massachusetts General Hospital. In both patients there was considerable retention of barium in both the upper and lower pouches as a result of torsion and constriction at the hiatus.

As above noted, a portion of the stomach may slide freely back and forth through the hiatus or it may be incarcerated and immobile. Incarceration is usually seen only in patients whose history extends over a period of years, and it will be noted that when incarceration is present the symptoms are almost constant. The symptoms are inconstant and change in degree with change in position when the hernia is freely reducible. If incarceration has occurred and if the hernia is therefore present in all positions and at all times, it may be noted as a gas bubble above the diaphragm and behind the heart. Its presence may thus be detected on films or fluoroscopy of the chest prior to the administration of barium.

The great majority of hiatus herniae lie chiefly to the left of the midline; but when

a large part of the stomach is involved it has a tendency to rotate on an axis through its cardiac orifice so that its greater curvature is uppermost, and it may then lie chiefly to the right of the midline.

The incidence of hiatus hernia is highest in individuals beyond the age of forty years and it has been assumed that they occur as a result of relaxation of the tissues within the hiatus esophageus. It should be noted again here that there is no attachment of the muscle fibers of the crura of the diaphragm to the lower esophagus. It is the belief of the author and of many others that the incidence of herniation through the hitaus is increased in those patients who are overweight or have relatively large abdominal tumors. Rigler and Eneboe[13] studied a series of pregnant women in whom 18 per cent of the multiparas showed herniae during the third trimester of pregnancy. Of the ten patients re-examined after delivery only three still showed their herniae. The author has seen one large hiatus hernia in a woman having a fibroid which extended to the umbilicus and has also seen two herniae during pregnancy. Of these two, one was completely gone following delivery and one was reduced to about 2 cm. in diameter.

Hiatus herniae may also be found in infants and young children. Miller, Parmelee and Sanford[14] have reported one in an infant of nineteen days, and others have also been reported in recent years.[15,16,17]

The symptoms of hiatus hernia vary in type as well as in severity and the term, "masquerader of the abdomen," which was coined by Harrington, has been adopted by many. In many patients the history is suggestive of gallbladder disease, and this history may even include sharp attacks of upper abdominal pain but no jaundice. The pain frequently goes through to the back but its point of origin should make the physician suspicious of hernia since it has a substernal component which is larger than its epigastric component. The history is frequently very suggestive of coronary disease since the distress may begin in the substernal region and radiate into the left chest and down the left arm. The final differentiation between coronary insufficiency and hiatus hernia may be quite difficult since both conditions may exist in the same patient, as reported by Moschowitz.[18]

An interesting clinical and experimental study of the rôle of the gastrointestinal tract in the production of cardiac symptoms has recently been carried out by Morrison and Swalm.[19] These authors observed that in a number of patients with angina pectoris indifferent results were obtained with the usual methods of management, but that when attention was also directed toward the gastrointestinal tract there was definite improvement. They were able to produce typical anginal pain and characteristic electrocardiographic changes by inflation of balloons in the lower esophagus and stomach and concluded that there was a reflex nerve pathway between the upper gastrointestinal tract and the heart. They, therefore, recommend frequent feedings of a bland diet together with effective doses of atropine or belladonna in patients with angina associated with gastrointestinal symptoms. Porter[20] has also reported a case in which the distribution of pain was that of angina pectoris and in which there were electrocardiographic changes associated with diaphragmatic flutter. The pain was absent and the electrocardiographic tracing normal during periods of normal function of the diaphragm.

Hiatus hernia may occasionally be associated with a secondary anemia of significant degree as earlier noted by Bock, Dulin and Brooke[21] and more recently by Harrington[1] in 11 per cent of 198 cases in which operation was performed. The anemia is usually the result of erosion of the mucous membrane associated with incarceration but may be due to actual ulceration or tumor.

Opinions vary as to the indications for surgical repair of the hiatus hernia, and it is probable that many are of little or no importance. Harrington[1] has established the general rule that they should be

repaired if more than one third of the stomach is involved and if the general condition of the patient warrants such a procedure. Repair should certainly be done if the amount of stomach involved is sufficient to permit its twisting upon itself or if the colon is also involved. In elderly patients whose general condition is poor, but in whom there is evidence of spasm of the diaphragm about the stomach, paralysis of the left phrenic nerve may give prompt relief and lasting benefit.

CONGENITAL HERNIA

The congenital herniae constitute the second largest group of diaphragmatic herniae. The group is of great interest because in it we find the greatest departure from the normal and also the greatest variation in the organs involved. They are often dramatic in their clinical course and may be the cause of death by asphyxia or as the result of intestinal obstruction.

Respiratory symptoms usually predominate over the intestinal symptoms in infants under one year of age, due to partial or complete collapse of one lung and displacement of the mediastinum. The diagnosis may be suspected within a few minutes after birth when the attention of the obstetrician or pediatrician is arrested by the abnormally weak cry of the infant. Cyanosis may also be present. Physical examination may show abnormal position of the heart with absent breath sounds on one side. These findings, either singly or combined, should be sufficient indication for roentgen examination of the chest and the suspected diagnosis may thus be immediately confirmed without the administration of barium. In children over one year of age the outstanding symptoms are usually those of recurring, partial intestinal obstruction, although dyspnea and cyanosis may continue to be present in variable degree.

It should be noted that an occasional patient with a congenital diaphragmatic hernia may live to old age without significant symptoms referable to the hernia, but

it must also be noted that such a patient may live for years without symptoms and later die as a result of the lesion. Such a case is that reported by Stoll.[22]

The most common site of congenital hernia is through a persistent left pleuroperitoneal canal, or foramen of Bochdalek, the left-sided herniae being approximately ten times more frequent than those on the right. Herniae through this opening are almost always of the false variety and thus suggest that the misplaced organs occupied this abnormal position prior to the completion of the membrane dividing the celomic cavity. The major portion of the small intestine and at least half of the large bowel is usually involved. The terminal ileum and cecum are frequently to be found within the chest, thus showing an associated incomplete rotation of the colon.

Less commonly, herniation occurs through the parasternal foramen of Morgagni and it is of interest that these are almost always (perhaps always) true herniae. The organs involved usually include only a segment of the transverse colon and omentum, but the antrum of the stomach has also been described in the opening.

Occasionally, herniae occur through other parts of the diaphragm, and they may open into the pericardial cavity.[23] Ladd[24] has described a case in which congenital hernia was associated with absence of the pericardium and Ochsner[25] has operated upon a patient in whom there was absence of the anterior mediastinum. Ladd has remarked that it is surprising that associated anomalies of the pericardium and diaphragm are not more frequent in view of their intimate developmental connection.

The great majority of congenital herniae involve one or more hollow organs and the correct diagnosis may thus be strongly suspected on films made without the use of opaque media. Solid organs, however, may also be involved, and in herniae occurring through the left side the spleen is usually lodged above the diaphragm. This causes no difficulty in diagnosis, but when only solid organs are involved, for example the

liver, the diagnosis is very difficult and the homogeneous area of density at the base of the lung may be interpreted as a collection of fluid.

In the past there was a tendency to postpone any attempt at operative repair of congenital diaphragmatic hernia until the child had reached the age of several years. Experience, however, has shown that the child with a large diaphragmatic hernia remains poorly nourished and underdeveloped even though he may be free from obvious respiratory embarrassment or evidence of definite intestinal obstruction. Ladd and Gross[2] believe that the policy of waiting has been responsible for the loss of many lives and they have shown that infants in the first forty-eight hours of life stand major surgical procedures extremely well. These same authors are strongly in favor of roentgen examination to confirm the history and physical findings, but point out that in many cases all of the necessary information may be obtained without the use of barium. An added risk of obstruction is thus avoided. Harrington[26] is likewise in favor of early operation in all cases in which the large or small bowel is involved. I have been impressed by the poor state of development and general health of several children in whom operative repair had been delayed, and have witnessed the rapid return to robust health after successful operation.

These views are, therefore, in contrast to those of Kerr and Steinberg[27] who state that "Interest in this condition is more academic than practical as far as the physician is concerned except, of course, when thoracentesis is contemplated."

TRAUMATIC HERNIA

Diaphragmatic herniae due to trauma are always of the false type and are similar to the congenital herniae as regards the variability of site and of organs involved. Hedblom[25] collected a large series of cases and found that about 90 per cent occurred in males and that 50 per cent were due to penetrating injuries. It seems likely that the number resulting from crushing injuries may be found to increase with the increase in automobile accidents.

The opening in the diaphragm usually extends the full length of the muscle fibers and runs radially from the central tendon to the chest wall. The tendency of the opening to be of this slit-like character is seen even in those cases in which the original injury was that of a small object, such as a rifle bullet. In these cases it seems reasonable to believe that the originally small opening enlarges along the course of the muscle fibers as a result of repeated passage of the abdominal organs through the opening.

The raw edges of the opening are conducive to the formation of adhesions and it is, therefore, understandable that the incidence of intestinal obstruction is higher in traumatic herniae than in any other group of diaphragmatic herniae. Operative repair is, therefore, indicated in all cases unless the general condition of the patient does not warrant such a procedure. Delay is hazardous since the operative mortality is greatly increased in the event of intestinal obstruction.

EVENTRATION OF THE DIAPHRAGM

Eventration of the diaphragm should be included in any discussion of diaphragmatic herniae since the differential diagnosis is often a difficult one. The condition is much more common on the left side than on the right and is rarely bilateral. The high but intact diaphragm may or may not be paralyzed and its motion may be normal, diminished, absent or reversed.[29]

Satisfactory roentgen demonstration of the elevated diaphragm is at times very difficult, although it is normally possible in the right anterior oblique or right lateral positions. A number of procedures have been suggested for demonstrating the diaphragm and for differentiating eventration from hernia but none has been found to be entirely trustworthy.

As a rule the symptoms resulting from eventration are not severe and the diagno-

sis is suspected only because of the abnormal findings on physical examination. A few patients experience distress in the region of the left costal margin due to collection of gas in the stomach and colon. It will be noted that the fundus of the stomach may be well above its cardiac orifice in these cases and that gas may thus be effectively trapped there.

Since the symptoms do not as a rule warrant such a procedure only a few attempts have been made to correct the deformity. Correction by plication of the relaxed diaphragm does, however, seem possible.

CONGENITAL ABSENCE OF THE DIAPHRAGM

Congenital absence of the diaphragm is an even rarer condition but one which must also be considered. That the condition is not incompatible with life is shown by the patient reported by Harris and Greene.[30] Their patient was thirty-one years of age and had two children. The pressure relationships between the abdomen and left hemithorax in such a case are definitely abnormal but are identical with those of the patient with a large false hernia of the congenital or traumatic type. The condition may thus be embarrassing and is of course not curable but is nevertheless compatible with life.

The only merit in including the rare anomaly of congenital absence with the relatively common condition of diaphragmatic hernia is to point out that the diagnosis is not possible except after careful exploration by a competent surgeon. It must be borne in mind that in many cases of congenital and traumatic hernia the remnants of the diaphragm cannot be demonstrated by roentgen examination, and yet in such cases sufficient diaphragm may be found to effect a satisfactory repair in almost all cases. Careful exploration should, therefore, be carried out in all suspected cases, since the danger of obstruction is a very real one if the condition is actually that of hernia.

SUMMARY

Diaphragmatic hernia is an uncommon condition but is met with in almost all branches of the practice of medicine.

The complete thoracic stomach is an extremely rare anomaly and apparently gives rise to few symptoms. The partial thoracic stomach with shortening of the esophagus gives rise to symptoms which are most often the result of constriction at the junction of esophagus and stomach. It is important that both of these conditions be differentiated from the much more common hiatus hernia, in which the esophagus is of normal length and in which satisfactory surgical repair may be done.

Early operation is recommended for all cases of congenital and traumatic herniae because of the danger of intestinal obstruction.

Congenital absence of the diaphragm may not be diagnosed prior to careful exploration.

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DEFORMITIES OF THE CHEST AND SPINE RESULTING FROM THORACIC DISEASE AND OPERATION: THEIR PREVENTION

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OMAHA, NEBRASKA

IT is not enough merely to cure a disease. Always, every effort should be made to restore a patient to as nearly a normal condition as possible. That is to say, a cure should be accomplished with the least possible functional, cosmetic and economic sacrifice.

Too often, as a result of specialization there has developed among surgeons a tendency to become somewhat thoughtless of the fact that the human organism is an intimately integrated functional unit. Thoracic surgeons as a group are no exception. In their zeal to improve or put right the organs within the chest they not infrequently fail to appreciate the importance of the thoracic spine as an integral part of the thoracic cage. As a result not a few unnecessarily disfiguring and crippling deformities have been permitted to develop and unfortunately once deformities have become established they are difficult or impossible to correct.

The preventable deformities with which we are concerned are the rotational and lateral curvatures of the spine which may be grouped under the caption of thoracogenic scoliosis. These are of two types, pleurogenic or empyema, and thoracoplastogenic or thoracoplasty scolioses. Since an understanding of the differences in the two types of curvatures and in the mechanisms of their production is essential to intelligent preventive and corrective management, they will be discussed in some detail.

The pleurogenic type is produced mainly by forces which act from within the chest and which are abnormal, namely, contraction of pleural scar, while thoracoplasty scolioses arise from forces which normally act upon the spine, in which forces, however, a disturbance of equilibrium has taken place.
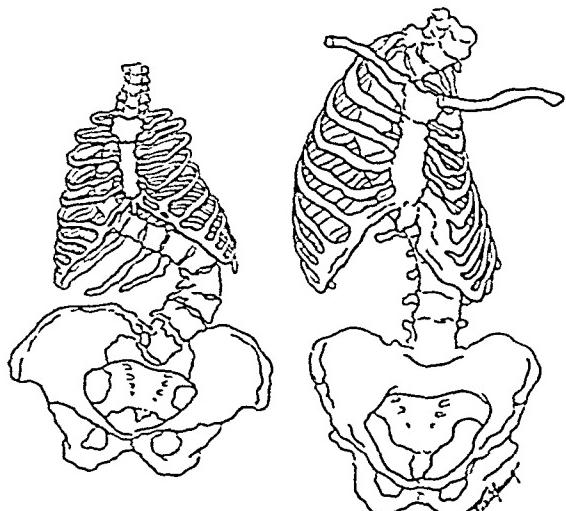
Fig. 1. Diagrammatic drawings for a comparative analysis of rotatory and non-rotatory scoliosis. To the left is illustrated the rotation deformity of the thorax of idiopathic scoliosis, which typifies the rotatory type of scoliosis. The drawing to the right represents the deformity of pleural scoliosis which uniquely is a nonrotatory type of curvature. (From Bisgard, J. D. Thoracogenic scoliosis. *Arch. Surg.*, 29: 417, 1934.)

The normal thoracic spine is maintained in a state of static equilibrium by a balance of the opposing forces acting on the two sides of the vertebrae, and the ribs are the principal agents of support by virtue of their rigidity not only as bony struts but also as instruments through which the forces exerted by the attached muscles and ligaments and the forces of intrathoracic pressures and stresses are transmitted to the vertebrae through their costovertebral articulations. Thus, normally, each pair of ribs grips with pressure the vertebrae with which it articulates; and if the pressure

is unequal on the two sides or if it has been removed from one side by the extensive resection of ribs, such as occurs in thoraco-

principally by the distortion resulting from the costal resection.

In the production of pleurogenic scoliosis

FIG. 2. Roentgenograms in a case of (a), thoracoplasty scoliosis, and (b) pleurogenic scoliosis. Compare with Figure 1. Note that the thoracoplasty curvature results from herniation or protrusion of the spine into the unsupported side and as such is a deficiency deformity whereas the pleurogenic curvature results from forceful bending and is a contracture deformity. (From Bisgard, J. D. Thoracogenic scoliosis. *Arch. Surg.*, 29: 417, 1934.)

plastic operations, the unopposed ribs push the vertebrae toward the unsupported side and a deviation results. A spine which was straight before operation will deviate with the convexity of the curve projecting into the side on which the operation was performed. This is the thoracoplasty type of scoliosis and results principally from removal of struts from one side of the vertebral bodies. It is a rotatory scoliosis as are all spinal curvatures with the exception of the pleurogenic type. That is, the vertebrae not only shift laterally but also rotate around the vertical axis as they deviate from it. As the vertebrae rotate they twist the costal framework so that the thoracic wall on the side of concavity, the unoperated side, becomes flattened posteriorly and bulged anteriorly. The deformity on the operated side is determined

two mechanisms are operative. First, as a result of pleural irritation and of pain there develops protective spasm of the muscles on the affected side and the spine is bent with the concavity of the curvature on that side. Thus there is an initial spastic scoliosis. Subsequently, the second and more important factor exerts its influence. The pleural scar resulting from chronic pleuritis from any cause, such as a simple serous tuberculous effusion or tuberculous or nontuberculous empyema, contracts gradually and through adherence to the ribs pulls them centripetally. Since the ribs, like bucket handles, can pivot only at their extremities (the vertebral articulations posteriorly and the cartilages anteriorly) and inscribe arcs as they are drawn mesialward, they also move downward. This force is transmitted to the

A   B

C

Fig. 3. An extensive fixed deformity which resulted from resection of ribs. A, roentgeno-
gram showing bronchiectasis of the right lower lobe, which had been filled with
iodized poppy-seed oil, 40 per cent. Note the slight sinister convex scoliosis. B, three
years after total excision of the right lower lobe after removing long segments of
three ribs. The spine has reversed its curvature and completely collapsed into the side
on which operation occurred. Note the rotation of the vertebrae and the deformity of
the thoracic wall caused by the rotation. C, photograph of the same patient illustrating
the characteristic deformity of rotatory scoliosis. (From Bisgard, J. D. Thoracogenic
scoliosis. Arch. Surg., 29: 417, 1934.)

vertebral bodies through their costovertebral articulations, traction being exerted on the uppermost thoracic vertebrae by

Fig. 2. ...

the upper ribs, which are pulled downward, and pressure being exerted on the lower ones, especially on those at the apex of the curve. The result is a spinal deviation with the convexity of the curve projecting into the healthy side, directed reversely to that produced by thoracoplasty.

The nature of the etiology of pleurogenic scoliosis makes it a distinct clinical entity. It differs from all of the other types in that there is no, or but slight, rotation of the vertebral bodies. This disobedience to the well recognized physical law of the dissipation of part of the bending force of rods into the production of rotation or twisting is due to the immobilization of the ribs in their retracted positions. The vertebrae cannot rotate against the resisting pressure exerted on them by the ribs, which are rigidly fixed by the pleural scar. This scar in certain instances undoubtedly exerts force directly on the vertebral bodies,

which help to prevent rotation and usually also tie the mediastinum to the spine so that it deviates with the spine. Since there is little or no rotation of the vertebrae, the thoracic cage develops only the distortion which results from lateral bending. The essential differences in the rotatory and nonrotatory types of scoliosis are illustrated in Figure 1 and 2.

Although most patients with pleural disease, many with pulmonary disease and all that have had extensive costal resections, develop some curvature or change in the alignment of their thoracic vertebrae. In only a few of them, fortunately, do the curvature progress to a stage of deformity or have any clinical importance. It should be noted also that deforming curvatures develop rarely in adults. All of the author's cases have occurred in children and adolescents. As stated in a previous publication, "Severe deformities are in most instances indictments of inadequate treatment because they are preventable. They are important, although they occur infrequently, because they are irreparable and because the extensive curvatures of the spine and distortions of the costal framework produce not only disfigurement of great concern to the patient, but also incapacity from impairment of cardiac and respiratory functions which not infrequently results in premature death." In Figure 3 is shown an extensive deformity which resulted from resection of portions of three ribs and the lower lobe of the right lung.

Disturbed anatomic relations of the heart and great vessels which impair their functional efficiency, and evidence of interference with the return flow of the pulmonary circulation with chronic passive congestion of the lungs have been observed frequently at necropsy (Eckardt 1927). These factors not only limit the patient's activities but also diminish his ability to combat any severe illness successfully. Pneumonia is a frequent cause of death.

Since it is difficult or impossible to correct established deformities, we should

concern ourselves principally with preventive therapy. Every child and every adolescent with pulmonary or pleural dis-

with the chronicity of the disease, and with a few exceptions, reflect improper treatment. The first objective in the pre-
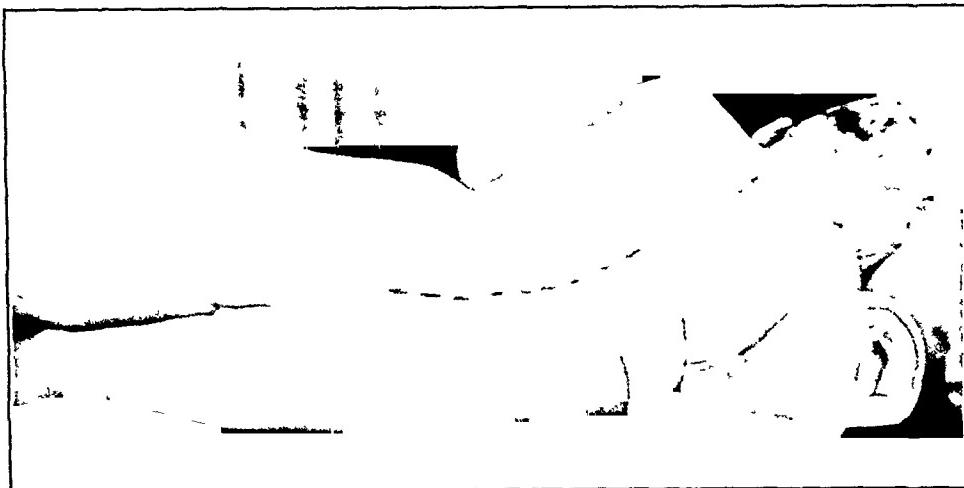
Fig. 5. Postural wedging to prevent development of a curvature in a case with empyema of the right pleural cavity. (From Bisgard, J. D. Postural wedge compression of thorax. *J. Thoracic Surg.*, 7:609, 1937.)

Fig. 6. A patient with a dependently drained encapsulated interlobar empyema of the left chest, lying upon a Bradford frame upon the affected side which, with the drainage tube, protrudes through the gap free from pressure. In this position drainage is dependent, the spine is bent into a position of overcorrection and the unaffected side has unrestricted motion. (From Bisgard, J. D. Postural wedge compression of thorax. *J. Thoracic Surg.*, 7: 609, 1937.)

case or who is undergoing operative treatment, which involves resection of portions of several ribs, should be considered a potential scoliotic and efforts to prevent deformity should be instituted immediately.

The spinal deviations resulting from muscle spasm associated with acute non-tuberculous empyema usually correct themselves when the empyema cavity is obliterated promptly. Deformities develop

vention of pleural scoliosis, is therefore, the early closure of empyema cavities by early, adequate and dependent drainage. The earlier the cure of the pleural disease the less will be the accumulation of scar tissue for subsequent contracture. One may use the analogy of cutaneous burns and the contracture deformities which result from them unless the granulating surfaces are rapidly epithelized.

In pure tuberculous effusions, rapid closure of pleural cavities may be effected only by repeated thoracenteses, because

The spine can be controlled and held in a corrected or overcorrected position most simply and most effectively by posture

A   B   C
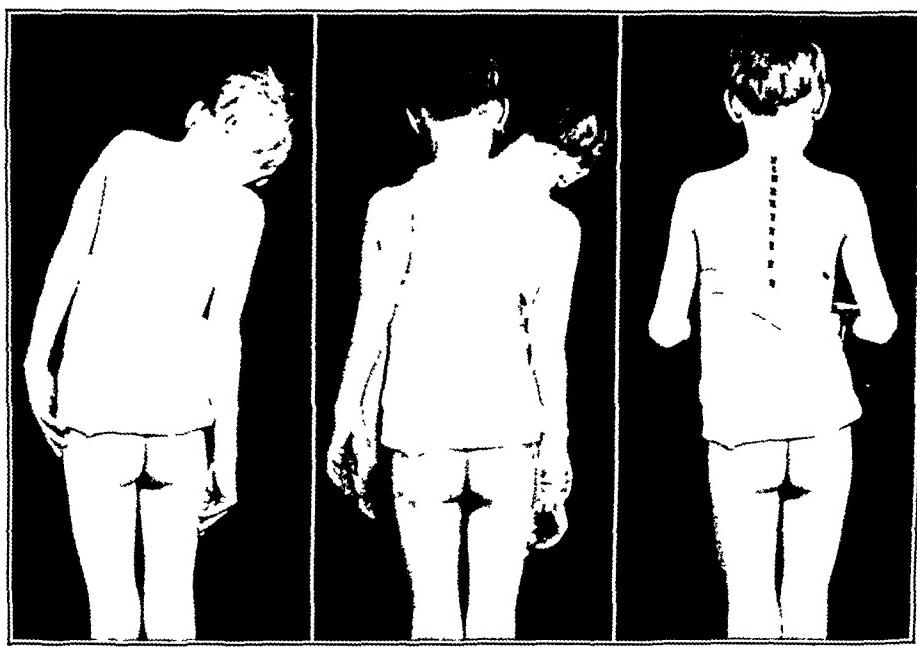
FIG. 7 A, B and C. Plaster body cast used in ambulatory treatment. It is applied with the thoracic, or primary, curvature exaggerated so that the spine is wedged straight over the edge of the cast. (From Bisgard, J. D. Postural wedge compression of thorax. J. Thoracic Surg., 7: 609, 1937.)

drainage is contraindicated, but drainage is applicable to many tuberculous effusions which are secondarily infected by pyogenic micro-organisms.

In all cases with pleural effusions, regardless of the etiology, a constant effort should be made to hold the spine in alignment or slight overcorrection during the major portion of each twenty-four hours during the period of active treatment. In cases which have developed evidence of curvature the above treatment should be continued for several months after the pleural cavity has been obliterated, in order to prevent deformity from latent contracture of the pleural scar. With the exception of infants and unco-operative children, this can be accomplished in most patients by posture; the patient lies on his side in such a way as to deviate the spine in the direction of overcorrection sufficiently to counteract the tendency to pleural scoliosis.

alone, or by bending the spine by postural wedging. In the latter procedure, illustrated in Figures 4 and 5, the patient lies on either side on a soft compression wedge, such as a pillow, which is rolled in the direction of the long axis and placed at right angles to the axis of the body. If this fulcrum is placed properly, the weight of the body wedges the spine in the direction desired. Preferably, postural wedging is accomplished with the patient lying upon the diseased side. The wedge is placed high in the axilla of that side (with the arm completely abducted and the head elevated) so that the entire thoracic spine is deviated in the reverse direction, the direction of overcorrection. Lying upon the diseased side is preferred because it permits dependent drainage, immobilizes that side and does not interfere with the free respiratory excursions and pulmonary ventilation of the healthy side. This position

can be maintained (whereas it might otherwise be impossible on account of pain) by anesthetizing the wound by commodate the buttocks, is shifted toward the head end sufficiently to leave the lower half of the chest unsupported. Thus the

A

B

Fig. 8 A and B. Postural wedging. An infant three months old with empyema of the right pleural cavity. Spine held constantly in overcorrection in a plaster of Paris bed with a removable restraining lid. (From Bisgard, J. D. Postural wedge compression of thorax. J. Thoracic Surg., 7: 609, 1937.)

crushing three intercostal nerves at the time of establishing drainage. It has been my practice to establish drainage by costal resection through the vertical incision advocated by Churchill. This permits easy exposure of one intercostal nerve above and one below the resected costal segment. These three nerves I routinely crush.

Several recent cases have been bedded upon Bradford frames as illustrated in Figure 6. A standard frame is suspended upon blocks in the usual manner so that it rests six or more inches above the surface of the bed. The gap between the canvas sheets, which ordinarily is placed to ac-

patient can lie comfortably and almost constantly upon the affected side, with the drainage tube protruding through the gap. With pillows under the head and shoulder, the dependent side will sag into the gap, diverting the spine into a position of overcorrection as shown in the photograph. Also with the affected side down, drainage may be made more dependent and the diseased side somewhat immobilized by the superincumbent weight, while the normal, unaffected half of the chest is given a maximum of unrestricted motion. The heart and other intrathoracic structures gravitate into the effected side, encourag-

ing obliteration of the empyema cavity and increasing the capacity for ventilation of the lung on the unaffected side.

Young children may be held in position for postural wedging in a plaster bed which is moulded to the body with the patient

Fig. 9. A, a tuberculous empyema of two years' duration in a child of four years has been productive of a moderately severe pleural scoliosis. B, the same patient two weeks after completion of a Schede thoracoplasty. Note the correction of the pleural scoliosis by the imbalance produced by the operation. (From Bisgard, J. D. Thoracogenic scoliosis. Arch. Surg., 29: 417, 1934.)

Of the methods of securing postural correction the use of the Bradford frame has proved the most satisfactory and will be used routinely by the author in the future.

If the curvature persists after the patient becomes ambulatory, correction can be accomplished and maintained by the use of a special type of plaster jacket. It is applied with the body bent to the affected side until the lumbar or secondary curvature has been corrected. The cast extends slightly below the greater trochanters on both sides and to the twelfth rib on the unaffected side. Very little padding is used, and the cast is made to fit very snugly. As the patient assumes an erect posture to establish balance, he automatically corrects the thoracic or primary curvature by wedging the spine over the edge of the cast. The principle is illustrated in Figure 7. This type of jacket should be worn for two or more months. After its removal, the patient should be seen at monthly intervals for at least a year, and with the slightest evidence of a recurrence of the curvature, the jacket or cast should be reapplied.

lying on the side in a position of overcorrection. The side walls should be high enough to prevent the child from rolling out of this position. A plaster of Paris bed is illustrated in Figure 8. Overcorrection in such a bed should be maintained for many weeks and until there is no tendency to recurrence of the curvature.

Although the vertebral column deviates or sags into the unsupported side of the chest after the extensive costal resections of a posterolateral thoracoplasty, the vertebrae are sufficiently plastic to permit considerable moulding and correction by force until it becomes fixed from four to eight weeks after operation by regenerated ribs, organized fibrous tissue and reinserted muscles. If correction is maintained during this reparative period, permanent curvatures will be minimized and often prevented. If, however, the periosteum has been destroyed or excised (as it is in a Schede thoracoplasty), the resected costal segments are not replaced, and the spine is permanently deprived of much of its support on the side on which operation has been performed. In many instances, how-

ever, this lack of support may compensate for the previous imbalance from the pleural scar and merely correct a preoperative pleurogenic scoliosis. Thus, as illustrated in Figure 9, the operation performed for the purpose of obliterating a chronic empyema cavity often corrects the curvature which is usually present in these cases. Not infrequently it overcorrects and replaces the pleurogenic by a thoracoplasty type of scoliosis. The postoperative prophylactic maintenance of correction by postural wedging in these cases is beneficial but less effective than in the cases in which the extrapleural type of operation has been done. It is desirable, therefore, to obliterate as much of the empyema cavity as is possible by extrapleural resection of ribs.

To prevent and correct thoracoplasty scoliosis, postural wedging should be instituted within a few days after operation and maintained for at least six weeks, or until the reparative processes have fixed the thoracic wall. The procedure is carried out with the patient lying on the operated side but with the wedge placed exactly opposite or slightly caudal to the apex of the curve, as illustrated in Figure 4.

With co-operation from the patient, postural wedge compression may be started immediately, or a day or two after operation, and within a few days may be maintained almost continuously.

Following thoracoplasty there is a tendency for the shoulder on the operated side to become elevated and if the costal resection has not been carried below the seventh rib the tip of the scapula may become caught on the ridge formed by the un-

resected ribs and hold the shoulder in an elevated position. This can be corrected by resecting the distal portion of the scapula.

The treatment of extensive and rigid spinal deformities belongs to the province of orthopedic surgery, so will not be discussed in this presentation. Suffice it to say that they are usually irreparable.

SUMMARY

1. Thoracogenic scolioses are of two types: pleurogenic and thoracoplastogenic. Both are preventable and are curable if corrected in their incipience. Extensive and rigid deformities of the spine and costal framework are incurable.

2. Pleurogenic deformities can be prevented by (1) the prevention of the formation of pleural scar by early cure of the empyema or pleuritis, and (2) the constant attention to maintenance of straight alignment or preferably of over correction of the spine. This can be accomplished by means of (a) postural wedging, (b) corrective body casts of plaster of Paris, and (c) resection of ribs on the side of concavity. To facilitate correction and the use of corrective measures, it is helpful to anesthetize the area of the wound by crushing the intercostal nerves which supply that area.

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SLIPPING RIB CARTILAGE

WITH REPORT OF CASES

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ABNORMAL mobility and the resulting deformity of the anterior ends of the anterior costal cartilages of the vertebrochondral ribs (the eighth, ninth and tenth on either side) causing painful symptoms and disability, have received but little attention in medical literature. Some textbooks, notably that by Key and Connell, make brief reference to this condition, but there is no general understanding as to what it is, why it occurs or how the symptoms are produced. It therefore seems wise to restate, to a large extent, my original paper, "A Study of the Slipping Rib Cartilage Syndrome," which appeared in the *New England Medical Journal*, 1941, comment anew on this symptom complex observed over a period of twenty-nine years, and make a further report of cases.

This syndrome has to do with the distal ends of the anterior rib cartilages, their interchondral articulations and the intercostal nerves. It does not involve the costochondral junction of the anterior ends of the ribs. Barring anomalies, mistakes in numbering the ribs, and exceptions, it involves only the anterior cartilages of the first three false ribs, anatomically designated vertebrochondral ribs, since their cartilages articulate anteriorly not with the sternum but with the cartilages of the ribs above. They are the eighth, ninth and tenth ribs on either side.

In the *Practitioner*, 1919, under the caption "On Various Conditions That May Simulate the Referred Pains of Visceral Disease and a Consideration of These from the Point of View of Cause and Effect," this symptom complex was first reported by Edgar F. Cyriax,[1] of the Medico-psychological Clinic, London. He specifically mentioned three cases treated expectantly.

In the *British Medical Journal*, 1922, under the original title "Slipping Rib," Davies-Colley,[2] Surgeon to Guy's Hospital, London, reported two cases of distal end anterior rib cartilage displacement which he had operated upon by resection of the loosened cartilages with "complete relief of symptoms." Davies-Colley[2] records that one of his patients had previously submitted to an exploratory laparotomy without relief of symptoms, but was immediately cured by the removal of the loosened cartilage.

Subsequently, and up to 1924, there were reported in the *British Medical Journal* under the heading "Slipping Rib," eight other cases by five authors,[3-7] three from England, one from Ireland and one from Egypt. Of these eight cases, three of the patients were operated upon with cure.

In 1931, two cases were reported in America, one by Dewey Bisgard,[8] from the University of Chicago clinics and one by J. A. Darby,[9] of Vancouver, Washington. Both of these patients were operated upon with cure.

Davies-Colley[2] noted: "It is probably not a rare condition and is a trivial enough complaint in itself but it gives rise to most irksome symptoms. . . . In its (the pain's) position at the costal margin it resembles that due to so many deeper lesions of the abdomen and thorax, that I think it is quite likely that many cases occur in which such an apparently unimportant cause as a movable rib cartilage is unsuspected and the diagnosis missed."

Slipping rib cartilage is of common occurrence, often producing symptoms that are sometimes of an incapacitating nature.

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Diagnosis is made by the history and physical examination. X-ray is helpful, by excluding deeper maladies of the thorax and abdomen. Cure is obtained by a simple operation.

Failure to recognize this symptom syndrome has led to needless laparotimes, prolonged suffering and varying degrees of incapacity. Then, too, while the condition has been recognized, there does not appear to be any clear conception of its development. It therefore seems important to present again the primary fundamental features of this syndrome in the hope that it will lead to a more general understanding and stimulate a greater interest in the subject.

This loosening deformity involves the costochondral articulations and the anterior ends of the anterior cartilages of the vertebrochondral ribs, namely, the eighth, ninth and tenth ribs on either side. It is produced first by the pulling away of the anterior end of the cartilage, and secondly by the curling upward of the loosened end, so that on motion the deformed end rubs against the inside of the rib above, causing pain; also on certain motions and manipulation the deformed end slips over the rib border with a click that is felt by the patient, and a pain that is sometimes severe and incapacitating.

Figure 1, an anatomical diagram of the framework of the anterior chest wall from Gray's "Anatomy"[10] recalls that the anterior ends of the anterior cartilages of the eighth, ninth and tenth ribs are normally connected to those above not by cartilaginous union, but by a fibrous attachment. Less clearly shown, but easily demonstrable, is a fibrous hammock supporting the cartilage ends and enclosing the interchondral synovial membranes of the costochondral articulations. This encircling type of attachment lends to the desirable mobility of the anterior chest wall and rib border, but at the same time it has the characteristic of instability of any joint and hence the susceptability to trauma. Important here to remember in the consideration

of cause and effect is a statement of Howard Lilienthal:[11] "The weakest part of the thorax is along the costo chondral line on either side." One should also have in mind, especially with reference to the development of symptoms, the various muscle origins and insertions with their divergent pull, the nerve supplies involved and the constant respiratory motions in this region.

The *intercostal muscles*, internal and external, occupy the intercostal spaces. Each arises from the lower border of the rib and costal cartilages above and are inserted into the upper border of the rib and costal cartilages below. Their fibers pass obliquely but in opposite directions, and extend from the tubercle of the rib behind to a point near the termination of the costal cartilage of the rib in front, where they end in a thin membrane. Their action is to stabilize the chest wall, particularly the intercostal spaces. Their nerve supply is from the intercostals.

Figure 2 pictures the diaphragm which arises from the back of the ensiform process, from the cartilages and adjacent portions of the six lower ribs, from the lumbocostal aponeurotic arch and from the lumbar vertebrae. From this series of origins it converges to be inserted into a central tendon. The diaphragm is the principal muscle of inspiration. During inspiration the lower ribs are fixed. Contraction of the muscle lowers the diaphragm, exerting a strong pull on the rib border. "In all expulsive acts the diaphragm is called into action to give additional power to each expulsive effort. Thus before sneezing, coughing, laughing, crying, or vomiting, and previous to the expulsion of urine or feces or of the fetus from the uterus, a deep inspiration takes place," throwing sudden and added strain on the rib borders. The nerve supply is from the phrenic and lower intercostals.

Figure 3 shows the *transversus abdominis* muscle which arises in part from the inner surfaces of the cartilages of the six lower ribs, interdigitating with the diaphragm to

be inserted into the crest of the pubes, the pectineal line and the linea alba.

Figure 4 illustrates the *obliquus internus*

*Fig. 1. Sternocostal and interchondral articulations, anterior view.[10]

These abdominal muscles act in executing and stabilizing trunk positions. They function in conjunction with the diaphragm
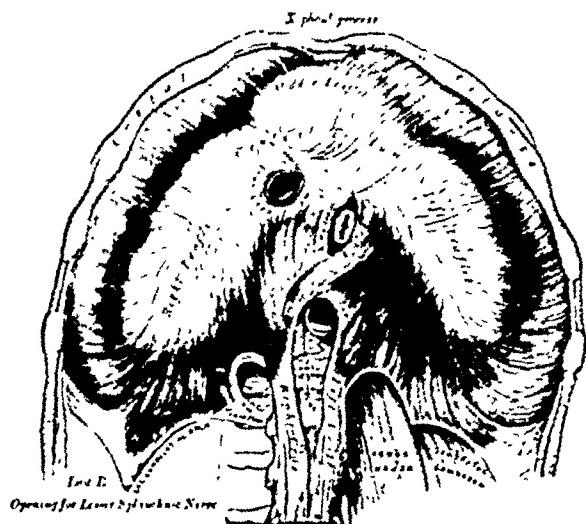
Fig. 2. The diaphragm; undersurface.[10]

abdominis muscle which arises by fleshy fibers from inguinal ligaments, the crest of the ilium and the lumbodorsal fascia. It is inserted into the pubic crest, pectineal line, linea alba and the cartilages of the six lower (the false) ribs.

Figure 5 represents the *obliquus externus abdominis* muscle which "arises by eight fleshy digitations, from the external surfaces and inferior borders of the eight lower ribs and their anterior costal cartilages; the five superior serrations . . . are received between the corresponding processes of the Serratus anterior; the three lower ones . . . between corresponding processes from the Latissimus dorsi." The muscle extends downward to be inserted into the anterior half of the crest of the ilium, and, opposite a line between the ninth costal cartilage and the anterior superior iliac spine, it ends in an oponeurosis which continues, to unite with its fellow of the opposite side, covering and partly enclosing the rectus abdominis.

* All illustrations are taken from Gray's "Anatomy," Twenty-third Edition. Edited by Warren H. Lewis, B.S., M.D., Philadelphia and New York, 1936. Lea and Febiger.

to compress the abdominal viscera in all expulsive efforts, and to compress the lower thorax in assisting expiration. "If the pelvis alone be fixed, the thorax is bent directly forward, when the muscles of both sides act, when the muscles of only one side contract, the trunk is bent toward that side and rotated toward the opposite side. If the thorax be fixed, the muscles, acting together, draw the pelvis upward, as in climbing; or, acting singly, they draw the pelvis upward, and bend the vertebral column to one side or the other." The nerve supply of the abdominal muscles comes from the lower intercostals and the lumbar plexus.

The serratus anterior, also shown in Figure 5, is a thin muscle situated between the ribs and the scapula on the lateral aspect of the chest. It arises by fleshy digitations from the outer surfaces and superior borders of the upper eight or nine ribs and rib cartilages, and from the aponeuroses covering the intervening intercostals. From this extensive attachment the fibers pass backward, are closely applied to the chest wall, reach the vertebral border of the scapula and are inserted into its ventral

surface. The serratus anterior functions as a whole to carry the scapula forward, and at the same time raises the vertebral border

climbing, and raise the lower ribs in forced inspiration. Its nerve supply is the long thoracic.
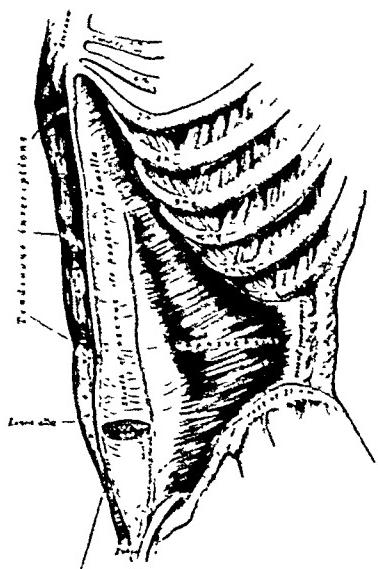
Fig. 3. The transversus abdominis.[10]
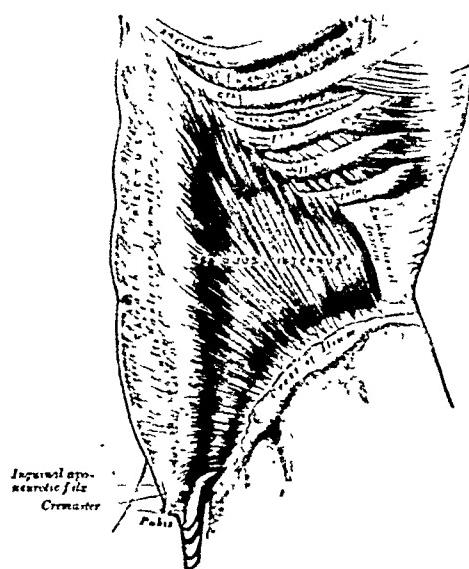
Fig. 4. The obliquus internus abdominis.[10]

of the bone. It is therefore concerned in the action of pushing. It stabilizes the scapula and assists the trapezius muscle in motions at the sternoclavicular joint, the deltoideus muscle in raising the arm, and may assist in raising and everting the ribs. The nerve supply is "by the long thoracic, which is derived from the fifth, sixth and seventh cervicals," by way of the brachial plexus.

The latissimus dorsi (Fig. 5) is a triangular, flat muscle, which covers the lumbar region and lower half of the thoracic region. It arises from the spinous processes of the lower six thoracic vertebrae, the lumbodorsal facia, the supraspinal ligaments and the external lip of the crest of the ilium. It also arises from the three or four lower ribs, interdigitating with the processes of the external oblique muscle. This muscle passes obliquely upward, crosses the inferior angle of the scapula, to which it is lightly attached, and converges into a tendon which is inserted into the upper anterior aspect of the humerus below the lesser tuberosity. Its motion is concerned with the downward pull of the arms, as in felling a tree and in sabre practise. It may assist the pectoral or abdominal muscles in bringing the trunk forward, as in

Posteriorly attached to the lower ribs, coming from above and below, are the deep muscles of the back, including the iliocostalis lumborum and the dorsi group, notably the longissimus dorsi. Their action is to assist in bending and stabilizing the spinal column and the trunk. Their nerve supply is the posterior primary divisions of the spinal nerves, closely associated with the sympathetics.

I have mentioned the muscles directly attached to the eighth, ninth and tenth ribs and their cartilages, but many other muscles and nerves are involved in the intricate mechanical processes of motion of the rib borders. The above is sufficient to suggest an explanation for the many signs and symptoms that characterize the syndrome of slipping rib cartilage.

ETIOLOGY

Abnormal mobility of the anterior ends of these anterior rib cartilages may begin acutely as a partial separation of the fibrous attachment. On the other hand, it may be the result of multiple injuries—stretching of the fibrous attachments over a period of time, as from golfing or one-sided weight carrying.

That trauma or injury, direct or indirect, is the etiological background seems reasonable. Ballan and Spector[13] report eight
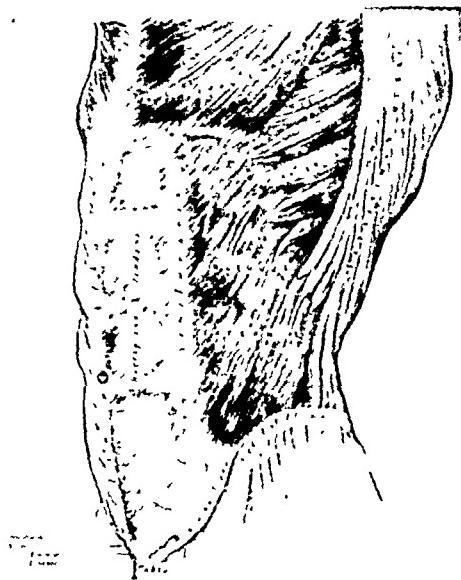
FIG. 5. The obliquus externus abdominis muscle, also indicating the serratus anterior and the latissimus dorsi.[10]

cases, under the title "Slipping Rib" and state in summary, "In most instances the slipping rib develops as a result of injury but that the patient frequently fails to attach any importance to the injury."

Deformity of the loosened rib cartilage end may result from displacement of a fracture, as appeared in one case; but usually it is due to the curling upward of the loosened cartilage end, so that the curled end rises above and to the inside of the superior rib cartilage, mechanically slipping up and down on respiration. It also slips out and in over the rib border on certain motions of the chest and arms, and on digital manipulation, with a click and a pain which is diagnostic.

From analyzing sixty-eight cases, fifteen reported prior to 1938,* seven by personal communication and forty-six of my own, it appears that slipping rib cartilage results more often from indirect than from direct trauma, there being thirty-six of the first and fourteen of the latter. In six cases, both

* The eight cases of Ballan and Spector are not included in this analysis.

direct and indirect force was in evidence. Of the twelve other cases no attempt was made to establish a cause due, I believe, to incomplete histories. It is usually necessary to retake the histories of these cases; for, since the cartilage deformity develops over a period of time subsequent to the trauma, the patient frequently does not associate the injury with the complaint and the cause is not recognized. This is particularly true of the cases of indirect injury.

An example of direct injury is the sudden application of a steering wheel against the lower ribs. Indirectly it may be caused by sudden flexion, extension, or twisting of the body, by repeated arm pulls, as in golfing, by a sudden pull on the arms in any form of lifting, by pushing, by the act of forced expulsion, as childbirth or coughing, and by many other types of force, any of which may cause or aggravate the condition.

In explaining the pain and tenderness associated with this syndrome, Cyriax[1] said, "Pain and tenderness produced by displacement of the anterior ends of the ribs or cartilages is doubtless due to irritation of the intercostal nerves in the vicinity, from which it may radiate to the posterior spinal nerves and thence to the thoracic or abdominal sympathetics." A diagram of the course and branches of a typical intercostal nerve, from Gray's[10] Anatomy, page 945, Figure 819, shows the logic of this statement.

According to Gray,[10] the intercostal nerves "pass forward in the intercostal spaces below the intercostal vessels. At the back of the chest they lie between the pleura and the posterior intercostal membranes, but soon pierce the latter and run between the two planes of intercostal muscles as far as the middle of the rib. They then enter the substance of the intercostals interni, and, running amidst their fibers as far as the costal cartilages, they gain the inner surfaces of the muscles and lie between them and the pleura. Near the sternum, they cross in front of the internal mammary artery and transversus thoracis muscle, pierce the intercostals interni, the

anterior intercostal membranes and pectoralis major, and supply the integument of the front of the thorax and over the mammae, forming the anterior cutaneous

tribution and communication of the thoracicoabdominal intercostal nerves may further explain the widespread and varying pain symptoms.
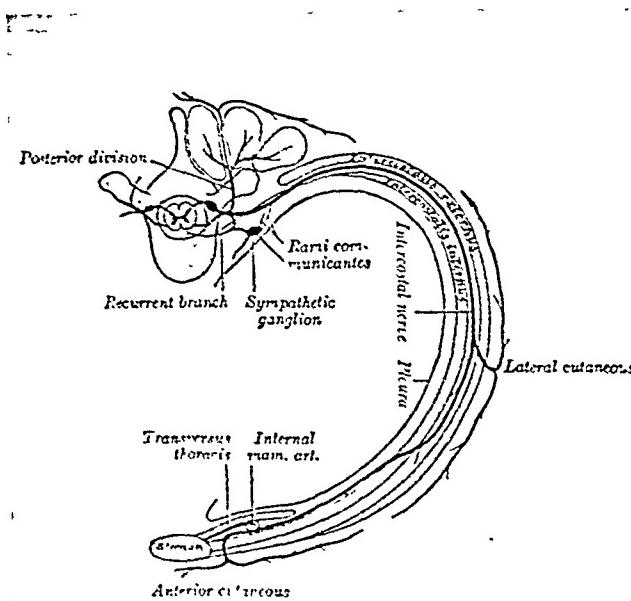
FIG. 6. Diagram of the course and branches of a typical intercostal nerve.[10]
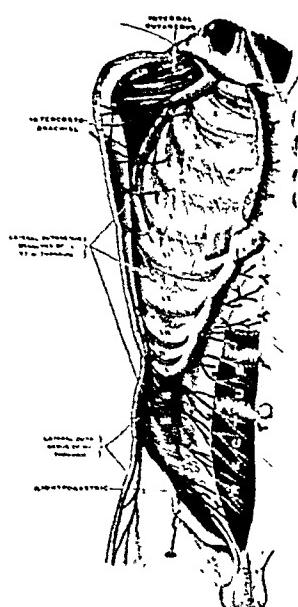
FIG. 7. Intercostal nerves, the superficial muscles having been removed (testus).[10]

branches of the thorax. . . . Each nerve is connected with the adjoining ganglion of the sympathetic trunk by a gray and white ramus communicans."

Another diagram from Gray's[10] Anatomy, page 947, Figure 221, further depicts the course and distribution of the thoracicoabdominal intercostal nerves (the seventh to the eleventh inclusive), their communication with the iliohypogastric nerve of the lumbar plexus, and particularly shows the close relationship at the costochondral junction of the vertebrochondral ribs, so that if the end of the vertebrochondral anterior rib cartilage becomes loosened, deformed and slips up under the rib cartilage above, there is a strong probability of nerve irritation. Substantiating this reasoning is the evidence that when the loosened and deformed cartilage is removed, the pain disappears immediately and permanently.

Keeping this diagram in mind, one can understand that the nerve above the lesion is particularly involved, and that the dis-

As pointed out by Cyriax,[1] and later by Davies-Colley,[2] the association of the sympathetic system with the intercostal nerves accounts for pain symptoms which suggest deeper lesions of the abdomen and thorax. Whether the interchondral joints which are involved in slipping rib cartilage contribute in any way to the pain manifestation is worthy of consideration.

Pathological examination of specimens obtained from these operations has shown nothing of interest.

Deformity of the loosened cartilage to produce the click usually develops secondarily, and therefore may not be recognized as coming from the original injury.

With these points in mind, I believe that a carefully taken history will, in all instances, show the etiology to be direct or indirect trauma.

DIAGNOSIS

Diagnosis of slipping rib cartilage is made from the history of pain in the chest or abdomen, usually, in part at least, at or

near the rib border, and over a period of time. Some of the patients complain of a slipping sensation or of something giving away at the rib borders, associated with pain. Others speak of bunches on, or of soreness of, the rib borders. By digital examination with the patient in the supine position and the knees flexed, an area of tenderness at the rib border is noted, especially when the examiner's fingers are well under the rib border and pressing outward. At the same time the abnormally movable rib cartilage, with its associated click and pain, may be demonstrated. The slipping rib cartilage is easy to demonstrate in some cases and difficult in others so that, given a suggestive history, and an area of tenderness at the rib border, a tentative diagnosis can be established and repeated examinations or examination under anesthesia made to confirm it. This is especially true of the acute case in which muscle spasm is likely to prevent satisfactory local examination.

The intensity of pain complained of is frequently well away from the rib border in the anterior chest wall, the breasts, the heart region, the shoulder blades, the back and the abdomen, but usually there is an associated general soreness of the "ribs" and an acute localized tenderness at the rib border. It is important to rule out other possible causes or factors, especially when the pain symptoms involve the abdomen and raise the question of an intra-abdominal lesion, and here x-ray examination is of great assistance. The same is true of the chest when a question of fractured rib is considered, either as a cause or contributory factor of pain.

Limitation of chest expansion as demonstrated by measurement is a suggestive diagnostic feature.[12]

Positions of carriage and action of the body and limbs are noteworthy. Some patients are bent forward and to the affected side, some cannot raise their arms without causing pain. Some have pain in bending forward and rising from a forwardly bent position, so that they accom-

plish this act by crouching and rising with the back straight.

It is of the greatest importance in diagnosis to have this syndrome in mind and also to have a clear understanding of its development.

TREATMENT

Cyriax[1] treated his patients conservatively, but other cases reported have been treated mainly by excision of the loosened cartilage. This has usually resulted in immediate and permanent relief of symptoms.

Personally, I have treated the acute condition conservatively by adhesive strapping. Later, in the course of one to three months or longer, if the symptoms persist, and with sufficient severity, I advise operation, excision of the loosened rib cartilage.

Some of my patients have, in part at least, recovered under conservative treatment; some of them have declined operation, preferring to tolerate the pain or are still considering operation. Those patients, twenty-two in number, whose symptoms had continued and who submitted to operation, were treated by excision of the rib cartilage or cartilages involved with excellent and often dramatic results.

OPERATION

The incision is made in the direction of the slope of the ribs, three finger-breadths above the umbilicus and centered at the anterior-axillary line; or starting at a point one finger-breadth anteriorly and above the tip of the eleventh rib cartilage (which can easily be felt) the incision is made in the direction of the slope of the ribs to the mid-axillary line. Having exposed the muscles, the operator's fingers are hooked under the rib border, and an examination made of the tenth, ninth and eighth rib cartilages, identifying the cartilage or cartilages involved. The surgeon supports the loosened cartilage with the fingers and the muscles are separated down to the cartilage which is to be removed and back to its articulation with the rib. After pushing the anterior muscle attachments away disarticulation is

performed, using a scalpel. The disarticulated end of the cartilage is grasped in double hooks, the muscle attachments, laterally and beneath, are dissected off and the cartilage removed. A further examination is then made of the adjacent cartilages for any abnormal notion or deformity. If found, these cartilages should also be removed. If not found, the incision is closed. Beginning at a point between the end of the operated rib and the rib above, a suture of plain catgut is taken through the intercostal muscles. To this point the adjacent intercostal muscles, previously detached from the cartilage, are drawn in for protection. Continuing with the same suture the external muscle rent is brought together and the skin incision closed.

CONVALESCENCE

Convalescence is usually uneventful. Temporary bowel and urinary inaction may be expected as the operation involves muscles that assist in these expulsive acts. The patient is immediately relieved of the "old pain" and leaves the hospital in from three to ten days. It is important to discriminate between the "old pain" and the pains that patients sometimes have following this, or any other type of operation; hence the value of a carefully taken preliminary history. Otherwise the immediate operative results may be wrongly interpreted.

ANALYSIS OF CASES IN WHICH OPERATION WAS PERFORMED

Of thirty-seven patients operated on, eight in the literature prior to 1938, eight by personal communication and twenty-one of my own, the ages ranged from six to fifty-seven years; the condition occurred on the left in fourteen cases, on the right in thirteen cases, and bilaterally in ten cases.

One rib was involved in twenty-one cases, two ribs in 11 cases, three ribs in one case and four ribs in four cases.

There was an area of tenderness at the site of the lesion in all cases. There was a wide variation in the character of pain. In some cases it was dull, in others sharp, especially on manipulation of the cartilage; in still others it was gripping or pulling. In some cases the pain was so modified that it was hardly recognized as such by the patients until questioned, and they frequently did not realize their handicap until they had been relieved of the annoyance.

Pain was constant in some cases; in some it occurred with different positions of the body or after certain types of muscle pull. Instances occurred in which remission of symptoms was brought about by rest from work or from forced rest in bed, occasioned by illness.

Following excision of the offending cartilage or cartilages, cure was obtained, permanent and usually immediate. There was no mortality.

CASE REPORTS

CASE I. F. T., a seventeen-year-old shoeworker, was first seen at my office on October 28, 1938. He stated that two days previously he caught his left sleeve in a roughing brush and was pulled up to the machine with a twisting motion, lacerating his upper arm. At that time, aside from the arm injury, he felt a sharp pain in the left rib border, and had noticed some soreness there since.

Physical examination revealed an abrasion and contusion of the left upper arm with infection, localized tenderness at the left rib border, and general soreness of the left anterior chest.

The arm lesion healed readily, but the chest symptoms persisted. One month later, an examination showed tenderness still present at the left rib border, and, on digital manipulation (the patient in supine position, with the knees flexed) the anterior end of the tenth anterior rib cartilage was found to be abnormally loosened and deformed—curled up under the rib cartilage above. It could be slipped out over the rib border, producing a click and a pain. The diagnosis was slipping rib cartilage of the tenth left rib. The type of force to produce this injury was indirect, from pull on the arm and torsion of the body at the time of the accident.

Treatment was conservative at first, the chest being strapped with adhesive plaster.

The condition grew worse, and the patient became incapacitated for work. On September 10, 1940, at the Sacred Heart Hospital, Manchester, New Hampshire, an operation was performed. The anterior end of the tenth anterior rib cartilage was found to be abnormally loosened and curled up under the rib cartilage above. On manipulation, it could be brought out over the rib border, producing a click. The loosened and deformed cartilage was excised. The patient was immediately and completely relieved of symptoms and left the hospital in six days. His convalescence was short and uneventful. He returned to work in about four weeks, has remained well and has worked steadily.

CASE II. A. F., a fifty-one year-old W.P.A. sewing project worker, was first seen at my office on January 10, 1940. She stated that on that day she caught her toe in the handle of a bulkhead door and fell on a concrete sidewalk with the left arm under her. At the same time she injured both knees. She complained of pain in, and general soreness of, the anterior chest with especial tenderness on the left side along the rib border, also of pain in the left upper arm and both knees.

Physical examination revealed general soreness of the anterior chest, particularly on the left side and more especially at the left rib border, contusion and discoloration of the left upper arm, laceration and swelling of both knees. The arm and knee injuries gradually healed but the chest symptoms persisted.

On April 11, 1940, her complaint was pain in the left rib border, aggravated by stooping, by lateral motion, by deep breathing, and by raising of the left arm. Examination showed localized tenderness at the left rib border, with a deformity and slipping of the anterior end of the ninth left anterior rib cartilage, associated with pain. The diagnosis was slipping rib cartilage of the ninth left rib. The type of force to produce this injury was direct, from pressure of the left elbow on the rib border at the time of the fall.

The treatment at first was conservative, consisting of adhesive plaster strapping of the left chest, but no relief was obtained. On April 23, 1940 (three months after the injury), an operation was performed at the Elliot Hospital, Manchester, New Hampshire. The anterior end of the ninth anterior rib cartilage was found to be abnormally loosened and deformed—curled up under the rib cartilage above. On manipu-

lation it came out over the rib border with a click. The ninth left anterior rib cartilage was excised. Disappearance of pain was indefinite at first, and convalescence was slow. On May 3, 1940, the patient was discharged from the hospital, relieved; but she did not return to her employment until about three months later. Since then she has worked steadily.

CASE III. M. A. F., a thirty-year-old domestic, was first seen at my office on February 23, 1940, at the request of Dr. Roland Joyce of Nashua, New Hampshire. She stated that on December 30, 1939, while riding in an automobile which was involved in an accident, she suffered a direct injury to her chest. She felt some pain, and the following day noted discoloration at the right rib border; but she considered her condition casual and did not see her physician until three weeks later, when she complained of pain at the rib borders, exaggerated by deep breathing or by twisting and flexing of the body. The symptoms became more severe until she was incapacitated for work.

Physical examination revealed a localized tenderness at the rib borders, with slipping and deformity of the anterior end of the tenth anterior rib cartilage, bilaterally. The diagnosis was slipping rib cartilage of the tenth rib, bilaterally. The type of force to produce this injury was direct, received at the time of the accident.

On April 8, 1940, an operation was performed at St. Joseph's Hospital, Nashua, New Hampshire. Examination at that time showed the anterior end of the tenth anterior rib cartilage on both sides to be abnormally loosened and deformed—curled up under the corresponding rib borders. On manipulation they could be brought out over the rib cartilages above with an audible click. The eleventh ribs and their anterior cartilages were abnormally long. The tenth and eleventh anterior rib cartilages on either side were excised, the eleventh being removed for symmetry in relation to the anterior ends of the tenth ribs. The patient made an early and complete recovery. On May 19, 1941, Dr. Joyce reported that she remained completely relieved and had worked steadily.

CASE IV. M. L., a twenty-year-old shoeworker, was first seen at my office on August 16, 1940. She stated that following childbirth fourteen months previously, she began to have pain in her right side. (In 193⁻ she had been operated

upon for gallbladder disease and the gallbladder removed, following which she remained well for two years.) After childbirth, when she began to experience pain in the gallbladder region, she felt that her symptoms were due to adhesions resulting from the gallbladder operation. The pain, which was definitely localized at the right rib border, became progressively worse, and she had been unable to work for one year.

Physical examination revealed general tenderness about the right upper quadrant of the abdomen and adjacent lower chest, with a localized area of tenderness at the right rib border. There was an abnormal mobility and a deformity of the anterior ends of the ninth and tenth right anterior rib cartilages, which, on manipulation, slipped out over the rib border with a click and a pain—recognized by the patient as her complaint. The diagnosis was slipping rib cartilage of the ninth and tenth right ribs. The type of force to produce this injury was indirect, from muscle pull in stabilization of the lower chest, and abdominal compression in the expulsive act of childbirth.

On August 27, 1940 (fourteen months after the injury), an operation was performed at the Elliot Hospital, Manchester, New Hampshire. The abnormal looseness and deformity of the anterior ends of the ninth and tenth right anterior rib cartilages were demonstrated and the two cartilages removed. The patient was immediately and completely relieved of symptoms and was discharged from the hospital in five days. She returned to her work one month latter and has remained well ever since.

CASE V. C. S., a forty-year-old cloth inspector, was first seen at my office on September 14, 1940, at the request of Dr. Joseph A. Sapienza of Lawrence, Massachusetts. The patient stated that on September 1, 1940, while lifting a heavy bolt of cloth from the floor, he felt a sharp pain in his right chest near the rib border. The pain had continued and was aggravated by deep breathing, stretching, coughing, bending of the body, or by any motion requiring the use of the chest muscles on the right side. The symptoms had become progressively worse and he was incapacitated.

Physical examination revealed that the pain point, of which he complained, was about two inches above the right rib border. The tenderness, however, was at the rib border, and the anterior ends of the ninth and tenth right anterior rib cartilages were found to be abnormally loosened and deformed—curled up under

the rib cartilages above. On manipulation, which was difficult because of acute muscle spasm, a click, with an associated pain, was demonstrated. The diagnosis was slipping rib cartilage of the ninth and tenth ribs. The type of force to produce this injury was indirect, from muscle pull in chest stabilization and abdominal compression during the act of lifting.

On September 23, 1941, at the Clover Hill Hospital, Lawrence, Massachusetts, an operation was performed. The abnormally loosened and deformed ninth and tenth right anterior rib cartilages were demonstrated and removed. The patient was immediately relieved, made an uneventful recovery and returned to work in about three weeks. On May 16, 1941, Dr. Sapienza reported him to be free of symptoms and in excellent health.

CASE VI. L. St. A., a twenty-two-year-old mill hand and laborer, was first seen at my office on March 25, 1941, at the request of Dr. R. C. Seed of Lawrence, Massachusetts. The patient stated that on January 16, 1940, while pushing a heavy truck, he felt a pain in his rib borders, especially on the left side. As he continued to work, the pain became worse from day to day. He felt it most severely while working, but was uncomfortable for some time after he stopped working. The symptoms became intensified, and after two weeks he was given a lighter job, at which he continued for eleven months. His complaint was pain at the rib borders, particularly on the left, while standing erect, while walking about, in kneeling, and in other motions of the body. He was incapacitated for work.

Physical examination revealed a localized tenderness at the rib borders, with an abnormal mobility and a deformity of the anterior ends of the ninth and tenth anterior rib cartilages on either side. By digital manipulation, these curled up cartilages could be brought out over the corresponding rib borders, producing an audible click, with an associated pain. The diagnosis was slipping rib cartilage of the ninth and tenth ribs, bilaterally. The type of force to produce this injury was indirect, from muscle pull in the act of pushing, and over a period of time.

On June 10, 1941, at the Clover Hill Hospital, Lawrence, Massachusetts, an operation was performed. The abnormally loosened and deformed ninth and tenth anterior rib cartilages on either side were demonstrated and removed.

On June 28, 1941, Dr. Seed reported that the result was very satisfactory; there had been no complaint of the old pain since the operation.

CASE VII. P. St. G., a six-year-old school boy, was first seen at my office on March 31, 1941. His mother stated that in August, 1940, she was riding in the back of a truck, sitting on an improvised seat and holding the child on her lap, when a collision with an automobile occurred. When she saw the imminence of the collision, she grasped the child tightly about the lower chest. Both were thrown forward, and the child came in contact with another board seat in front, bruising his left rib border. He was taken to a hospital, x-rayed, and examined by a physician. Subsequently, he was re-examined by another physician and x-rayed at another hospital, with negative reports. Meanwhile he had complained of pain at the rib borders, particularly on the left side. He cried, walked with his body bent forward, and could not play like other children, because of pain at the rib borders.

Physical examination showed his general condition to be good. There was tenderness at the rib borders, and on digital manipulation the anterior end of the tenth anterior rib cartilage on either side was found to be abnormally loosened and deformed—curled up under the corresponding rib cartilage above, and when brought out over the rib border, produced a click, with an associated pain. The diagnosis was slipping rib cartilage of the tenth rib, bilaterally. The type of force to produce this injury was direct, from pressure of the mother's arms, and from contact of the chest with the seat in front at the time of the accident.

On June 12, 1941, at the Hillsborough General Hospital, Grasmere, New Hampshire, an operation was performed. The abnormally loosened and deformed tenth anterior rib cartilage, on each side, was demonstrated and removed. The patient was immediately relieved of his symptoms and was discharged from the hospital on June 24, 1941. There has been no complaint since and the child walks and plays in his natural way.

CASE VIII. B. B., a seven-year-old school boy, was first seen at my office on May 5, 1941. His complaint was of intermittent pain across the upper abdomen. His mother stated that he had a severe attack of whooping cough in April and May of 1940. The pain attacks in the upper abdomen began in July, 1940. They became worse, and the mother thought they might be due to appendicitis. Recently the child was examined at a clinic where the mother was told that he did not have appendicitis. He continued to have abdominal pains, and his mother then wondered if they might be due to adhesions from a hernia operation performed two years previously. During the two weeks just passed, the pain attacks had been more severe and more frequent, occurring every day, and on the day before he had suffered six attacks.

Physical examination showed the patient to be fairly well developed and nourished. He walked with a stoop and held himself rather tense. There was localized tenderness at both rib borders, and the anterior end of the tenth anterior rib cartilage on either side was found to be abnormally loosened and deformed—curled up under the corresponding rib cartilage above, and on digital manipulation could be brought out over the rib border, producing a click with an associated pain which corresponded to the symptoms. The abdomen was negative. The previous hernia repair was in excellent condition with no evidence of recurrence. The diagnosis was slipping rib cartilage of the tenth rib, bilaterally. The type of force to produce this injury was indirect, from the muscle pull in coughing, which began in April and May of 1940, during the attack of whooping cough; but the deformity to produce the pain developed later so that the etiological factor in the case was obscure.

On May 6, 1941, at the Elliot Hospital, Manchester, New Hampshire, an operation was performed. The loosened and deformed cartilages as previously described, were demonstrated and removed. On May 8, the patient stated that the pain was gone, and on May 12, six days after the operation, he was discharged from the hospital. He has remained entirely free from symptoms and walks in a normal way.

SUMMARY AND CONCLUSIONS

1. Slipping rib cartilage is a definite lesion involving the anterior ends of the anterior cartilages of the vertebrochondral ribs, namely, the eighth, ninth and tenth on either side. It is not concerned with the costochondral articulations.

It is due to a loosening of the fibrous hammock-like attachment of the anterior end of the cartilage, and the loosening is

followed by deformity—a curling upward of the cartilage end—so that it rises to the inside of the rib above and comes in close relation to the intercostal nerve which is the seat of pain.

It is always of traumatic origin, either direct or indirect, more often the latter.

It occurs singly, and as multiple and bilateral lesions.

Age or sex are of no consideration.

2. The cartilage deformity develops over a period of time subsequent to the injury. The patient frequently does not associate the injury with the complaint, and the cause is not recognized; this is particularly true of indirect injury.

Since the rib border is the weakest part of the chest wall, a direct injury, even of minor severity, may cause the lesion, especially in the nonathletic.

Due to the muscle attachments and the different directions and degree of muscle pull, this loosening may occur in many ways.

There is a wide distribution of nerves involved, namely, the intercostals connected with the sympathetic system, and the brachial and lumbar plexuses. By way of the sympathetics, the intercostal nerves are connected with the cardiac, the solar or epigastric, and the hypogastric plexuses which, in turn, have branches to the viscera.

Thus the pain manifestations cover a wide field. The intensity of pain complained of is frequently well away from the rib border—in the anterior chest wall, breast region, shoulder blades, back, abdomen, and so forth; but usually there is an associated general soreness of the "ribs" (so spoken of by the patient), and a localized area of tenderness at the rib border.

3. Diagnosis is made from the history of pain in the chest or abdomen over a period of time. Usually the pain is in the anterior chest, at or near the rib borders.

There is a localized area of pain at the rib border, the site of the lesion.

By digital manipulation, with the patient in the supine position and the knees flexed, the abnormally loosened and de-formed cartilage can be brought out over the rib border with a click and a pain that is diagnostic.

X-ray examination is of assistance in ruling out deeper lesions of the chest and abdomen.

4. The pain of slipping rib cartilage is not like other pains. It is usually a dull ache and is often tolerated for years, even a life time. Some patients scarcely realize that they are impaired until operation is performed and their annoyance is taken away. Others suffer severely, and are acutely and completely incapacitated.

There are many cases of obscure pain associated with the chest and abdomen which may have as their background the slipping rib cartilage. Therefore, examination of the rib borders should be made routinely, and information relative to the syndrome should be generally disseminated.

The acute condition should be treated conservatively. Later, in the course of from one to three months, if the symptoms persist and with sufficient severity, excision of the loosened, deformed cartilage or catilages involved should be advised. Operation results in permanent and usually immediate relief of symptoms. There has been no mortality.

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Editorial

INTRACTABLE PEPTIC ULCERS—ARE THEY A SURGICAL OR A MEDICAL PROBLEM?*

IN any discussion of the treatment of peptic ulcer, there always arises the question of what is to be done with the patient who does not get relief from the usual treatment or the one who gets repeated attacks of ulcer symptoms in spite of careful dieting. In the many reports of the results of treatment for ulcer, in which the percentage of "cure" by medical treatment is estimated usually at from 70 to 80 per cent, it is assumed that the other 20 to 30 per cent of cases are "intractable ulcers," for which surgical treatment is indicated. Surgeons, finding that results of the older types of operation in these cases have not been reasonably successful, have become more and more radical in their operative procedures, until now subtotal gastrectomy is unblushingly recommended for even uncomplicated duodenal ulcers. Pharmaceutical houses, seeing here a fertile field for newer forms of medication, have outdone each other in producing preparations which will cure even intractable ulcers. The result is that now we have a very imposing array of drugs for oral and parenteral use, each of which can be tried in turn in any stubborn case, and credit for a cure is given to the one which happens to

be administered at the time symptoms may subside spontaneously. The fruitless and often acrimonious discussions of the treatment of ulcer by adherents of the different forms of therapy, which have made this subject taboo at polite medical meetings, should be considered an indication that no treatment by medicinal preparations is uniformly successful and that usually no treatment of the ulcer itself is required unless rest and frequent feedings of bland food have failed to relieve symptoms and repeated gastrointestinal studies have shown persistence of ulcer findings. There is at present no criterion of "intractability" in ulcer. Whether the term is to be used to describe the cases in which prompt relief of symptoms is not obtained by the usual dietetic or medicinal measures, whether it shall refer only to an unusually long period of symptoms before the patient has been put on an ulcer régime or whether unusually frequent recurrences of ulcer symptoms shall be the criterion, has never been established. Any one of these situations has in the past been deemed a sufficient reason for radical operative procedures, often to the detriment of the patient and to the chagrin of the surgeon.

* From the Gastroenterological Service, Long Island College Hospital. Read before the Section on Gastroenterology and Proctology, Meeting of the A. M. A., June 6, 1941.

In order to establish a satisfactory treatment for an intractable ulcer it is necessary to know the reasons for the intractability; and in order to understand why some ulcers are intractable, it is well to review briefly what is known about the etiology and course of peptic ulcer. Confronted by a constantly increasing array of reports of work being done in the experimental production of ulcers in animals and of their prevention or cure by various measures, with their apparent applicability to human ulcers, the clinician is led to believe that the production of ulcer is largely the result of acid erosion of the gastric or duodenal mucosa and that treatment directed to alkalinization is absolutely necessary for healing. And yet how contrary to fact and experience is this conception of ulcer. In the early days of experimental production of ulcers, before extensive mechanical procedures were instituted which undoubtedly have often interfered with healing, it was held that ulcers in animals were not like human ulcers, because they healed spontaneously with such rapidity. In the human, on the other hand, it has long been insisted upon that a diagnosis can almost certainly be made from the typical history of recurrent attacks of ulcer symptoms, with intervals of freedom from symptoms, and each attack self-limiting, even though the patient has seen no physician, has not suspected that he has had an ulcer and has gone through his attacks with no treatment at all unless he has discovered that temporary relief of symptoms could be obtained from food or alkali. From such a history one must be led to believe that ulcers either heal or become temporarily quiescent without treatment and in the presence of acid gastric juice. Repeated roentgenologic and gastroscopic observations of ulcers in patients who have received no treatment at all or at least no anti-acid treatment, have demonstrated the complete and rapid healing of ulcers while they were being bathed in highly acid gastric juice. It has long been my opinion that the gastric juice, by keeping the ulcer surface clean and perhaps slightly irritated, may actually promote healing. My experience of thirty years in the treatment of ulcer without any attempt at acid neutralization has shown just as good if not better results than in those cases in which some such anti-acid treatment has been used. After all, it is safe to assume that an uncomplicated ulcer will heal spontaneously if given a chance and that treatment must be directed to relieving the patient of hunger pains by frequent feedings of bland food while the ulcer is healing.

But what about the etiology of peptic ulcer? In spite of many experimental observations, one finds most authors stating that the cause of ulcer is not known. Although Rosenow[1] twenty-eight years ago demonstrated the relationship between peptic ulcers and focal infections, and although clinical experience in the thorough eradication of all focal infections has shown that only by this procedure can one be reasonably certain of preventing recurrence of ulcers, these observations have not been generally accepted as evidences of such an etiologic relationship. This has been largely due to the fact that confirmation of Rosenow's work was not conclusive, largely due to a difference in the technic used in the experiments. Rosenow having attributed the ulcers to infection by the Streptococcus viridans, it was natural that most later experiments by other workers were made with the intravenous injection into animals of pure cultures of these organisms with resulting failure to produce ulcers. Rosenow, in most of his work, injected suspensions of material obtained directly from the infective foci in which the organisms were found to be present on culture. This material contained more than organisms. It contained undoubtedly not only living and dead organisms and their products, but also tissue from the site of the infected area, more or less destroyed by the growth of the organisms, as well as phagocytes and other factors concerned with the local infection. And this fact brings us to the little noticed but pains-

taking and scientific studies of Fenton B. Turck,[2] who demonstrated the production of typical indurated ulcers in dogs following the intravenous injection of extracts made from macerated tissues of the same animal or of another animal of the same species. He attributed the production of the ulcer to a toxin which he at first called cytolysin and later cytost, present in dead tissues, and which, when injected, would produce areas of focal necrosis in various parts of the body, usually where there was an end artery, as along the lesser curvature of the stomach. Three entirely independent observations seem to confirm Turck's findings:

1. The presence of cytost in Rosenow's suspensions or its absorption from infective foci would explain the production of ulcers and other lesions entirely independent of infection, bacterial migration taking place later because of the production of proper "soil conditions" at the new focus.

2. The absorption of cytost from extensive burns of the skin, from comminuted bone fractures and from fields of operation would account for the hitherto unexplained occurrence of ulcers following such injuries. It brings up the question whether the changed physiological processes following experimental operative procedures in animals produce the ulcers observed to follow these procedures or whether they are caused by absorption of cytost from the operative field. In humans, the perforated ulcers following cholecystectomy, appendectomy or pelvic operations can be explained on this basis.

3. The pathological work on ulcer done by Lewis Gregory Cole[3] and confirmed by many pathologists, demonstrates that peptic ulcers start as areas of focal necrosis under the mucosa undoubtedly due to some blocking of the circulation, as from an obliterating endarteritis or arterial spasm, breaking through the mucosa much as boils do in the skin and healing rapidly, with more or less scarring depending upon the size of the ulcer and its location. If the necrotic area is deeply located near the serosa, it may break through the serosa alone, producing adhesions, or in conjunction with a break in the other direction, producing perforation. Involvement of blood vessels in the necrotic area accounts for hemorrhage. The rapid attraction to the necrotic and later ulcerating area of all cells and fluids having to do with healing accounts for the induration, edema, round cell infiltration and rapid healing, with larger and smaller areas of cicatrization depending upon the size and location of the ulcer. Deeply located necrotic areas, with serosal reactions or with partial or complete but walled-off perforations, often producing cysts or abscesses protected by plastic exudates or by adhesions to neighboring organs, account for the finding of perigastric and periduodenal adhesions to omentum, gallbladder, biliary tract and pancreas. These excessive reactions with resulting dense scarring, horny induration, deforming adhesions and obstructions may produce persistent symptoms due to their actually interfering with the healing of the ulcer or to the production of symptom producing complications.

That there are such things as *allergic ulcers* has been amply demonstrated. Usually multiple, they resemble "canker sores" and heal in the same manner. They produce very aggravated ulcer symptoms, and may often be the site of severe hemorrhages, small size and rapid healing accounting for the absence of roentgenologic evidences of the cause of the bleeding. Recently we have seen through the gastroscope such ulcers resembling small erosions in three cases of recurrent gastric hemorrhage in individuals known to be victims of food allergy. Whether Turck's ulcers were really allergic in origin or whether all ulcers are allergic manifestations, due to sensitization to some substance produced at the site of an infective focus, an operative field or an extensive area of necrosis of tissue, is still open to question. The fact remains that most ulcers develop after there have been symptoms of some acute infection elsewhere or of increased activity or after some

operative procedure at a previously existent infective focus. In a susceptible individual the occurrence of ulcer symptoms after such a story is a perfectly normal situation and can be demonstrated to be due to an entirely new ulcer and not to intractability on the part of an ulcer previously demonstrated.

In discussing intractability of ulcer, it has frequently been considered proper to consider *symptoms* the criterion of intractability. However, the *hunger pains* of ulcer, due to excessive hunger contractions in a stomach made irritable by the presence of the ulcer, may persist for a time after the healing of the ulcer can be definitely established. Hunger pain due to repeated or continuous though often small allergic ulcers will persist until the foods to which the patient is sensitized are removed from the diet. The *persistent pains*, often immediately aggravated by food, seen in the deep or serosal type of ulcers, and due to peritoneal irritation or distention by the pressure of food extruding into the deep crater, usually subside with healing of the ulcer; but, if actual walled-off perforation has occurred interfering with such healing, these pains may be quite persistent and may call for operative relief, even when their cause has not been recognized. *Pains referred* to other regions co-incidently diseased, as in the case of the right subcostal pains in which biliary tract disease is a complication, the right lower pains occurring with ileocecal or appendiceal pathology or the left lower pains of sigmoid or pelvic disease, are often a confusing factor. If due to ulcer, these pains usually occur at the hunger period and disappear with ulcer healing, but if due entirely to the co-incident disease they may occur at any time and may persist even though the ulcer is healed. If the character of the pains occurring in ulcer is carefully studied, confusion with the pains of cardiac or pulmonary lesions or of tabetic crises can usually be avoided. The *retrostaltic symptoms*, fulness, heartburn, belching, sour eructations or regurgitations, may be due to the ulcer itself, to complicating causes or only to habit. The *vomiting*, which may be retrostaltic in origin or due to the presence of an ulcer at or very close to the pylorus, may disappear with the subsidence of the swelling around an active ulcer, or may persist, due to the subsequent development of a real organic obstruction from a scar or from perigastric or periduodenal adhesions. The *hemorrhage*, when mild, due to surface bleeding or capillary oozing, will usually subside rapidly with healing of the ulcer. Severe hemorrhages due to small deep multiple ulcerations or to the tearing across or erosion of a vessel involved in the necrotic process, while usually subsiding quickly in ordinary cases under proper care, may be quite intractable in the presence of marked horny induration or of dense adhesions holding a vessel stiffly open. In such cases even operative interference may be futile.

From the foregoing discussion it is readily seen that if operative measures are to be instituted for the treatment of intractable ulcers, it is not wise or safe to use symptoms as a criterion of intractability. As has been pointed out, symptoms may be persistent even though an ulcer has healed completely and satisfactorily, and it is in such cases that so often unnecessary and even decidedly harmful operative attacks upon the stomach have been made in the hope that short-circuitings or excisions might influence symptoms or prevent recurrences of ulcers. The only true criterion of intractability is one based on anatomical findings as observed by standard procedures such as gastric analysis and roentgenological or gastroscopic studies repeatedly performed, and in the following discussion the subject will be discussed from that viewpoint. It is convenient to divide the cases with persistent ulcer symptoms into three groups: those showing no roentgenological evidence of ulcer, those showing evidence of the presence of an uncomplicated ulcer and those with evidence of complications:

1. *In the absence of roentgenological evidence* of the presence of an ulcer even though typical and persistent ulcer symptoms are present there may at times be also no evidence of ulceration by either gastroscopy or gastric analysis, the gastric irritability being due either to psychoneurological factors, to nonulcerative allergic reactions or to the fact that the ulcer causing the irritability has healed before the observations are made. Or on reviewing the case it may be found that the symptoms may not be typical of ulcer but may be of cardiac, pulmonary or tabetic origin. However, in many cases visible blood may be seen in the gastric contents during fractional removal and there may or may not be evidence of disturbed secretion. In these cases, gastroscopy may often reveal the lesion causing the symptoms and findings: there may be a small single ulcerative lesion suspicious of early malignancy or there may be multiple small mucosal ulcers suggesting an allergic origin. In the latter cases a study of the patient's allergic reactions to food or other substances should establish the diagnosis, should reveal the causes of the gastric mucosal reactions and should therefore indicate the method of successful treatment, usually merely abstinence from the foods causing the reactions. In the cases suspected of malignancy, repeated observations should be made to determine whether the lesion heals, indicating its benign nature, or whether it shows no tendency to heal but rather to increase in size, indicating its malignancy. In the rare cases in which through a rigid gastroscope a biopsy specimen might be obtained from such an area, a very early diagnosis could be made and a fine chance for surgical cure would be available.

II. *Where roentgenologic evidence of an uncomplicated ulcer is present* in stomach or duodenum, and the symptoms and signs do not subside in the usual manner, several explanations for their persistence may offer themselves:

1. The most important reason may be that the diagnosis was incorrect, that what was thought to be a simple gastric ulcer was really a carcinoma. In such cases early gastroscopy may at times show the typical appearance of malignancy and there may be a persistence of blood in the gastric contents on repeated observations. However, on repeated roentgen study within two to four weeks the persistence or increase in size of the ulcer crater and defect or their beginning irregularity of outline should occasion a very definite suspicion of carcinoma and indicate immediate wide excision of the affected area, even though at operation the gross findings might not be typically those of malignancy.

2. The persistence of the ulcer may be due to the fact that it is due to a specific infection, such as a tuberculous or syphilitic ulcer, although such ulcers more closely resemble carcinoma than simple ulcers. The tuberculous ulcer may take a long time to heal; the luetic one may clear up quickly under thorough antisyphilitic therapy, although both may leave deformities which would make exploration, because of the possibility of malignancy, desirable.

3. Unless careful comparison of films is made, the ulcer found on later observations and really a new ulcer at a different location in stomach or duodenum, may be mistaken for persistence of original ulcer. Such development of successive ulcers is not uncommon and is usually due to recurrent activity or operative attack upon some infective focus, to some new local or general infection or to an allergic reaction, the history being often quite clear in regard to one of these factors. No operative interference is necessarily indicated in such a case, as the new ulcer may go on to the usual spontaneous cure.

4. A persistence of the symptoms and roentgenologic signs of ulcer may be due to *complications* which may have been present but overlooked in the original study of the case. Such complications may be of several types, as follows:

A. They may be inherent in the ulcer itself, as in the case of a marked horny induration keeping the ulcer from healing,

of external adhesions and deformities keeping its edges apart or of actual walled-off perforation accounting for the persistent crater seen in the roentgen films.

B. They may be lesions in stomach or duodenum which tend to irritate the ulcer and interfere with healing, or to cause persistence of symptoms even after the ulcer has healed. Adenomas or diverticula or even a severe gastritis or duodenitis may be included in this group. Treatment will depend upon the nature of the lesion.

C. They may be lesions in other parts of the gastrointestinal tract and its appendages, such as the biliary tract, pancreas, appendix, colon and rectum, which by reflex or retrostaltic irritation or in the case of the biliary tract and pancreas, by contiguity or adhesions, aggravate and prevent the rapid healing of the ulcer. Such cases may require operation for relief of the persistent symptoms.

D. They may be lesions located outside of the gastrointestinal tract, acting entirely through a reflex mechanism, or also through contiguity or adhesions to the gastrointestinal tract, producing retrostaltic phenomena, either keeping an ulcer from healing or causing posthealing persistence of symptoms. Lesions of the pelvis or the urogenital tract are included in this group, and in these cases also operation may be necessary.

E. The complications causing persistence of signs or symptoms of ulcer may be endocrine in character, with thyroid, parathyroid, pituitary, adrenal or gonadal dyscrasias occasionally responsible and requiring appropriate treatment.

5. At times the actual *treatment may be responsible* for the long continued failure of healing of an ulcer. A diet containing insufficient vitamins, the use of alkalis to the point of alkalosis or the employment of drugs to which a patient is allergic may surely prevent and prolong such healing. It is therefore important, before declaring an ulcer intractable, to be sure that a safe and adequate course of treatment has been previously prescribed and carried out.

III. *Complicated ulcers* should usually be recognized at the time of the original study of a case. Marked deformities in the prepyloric or postpyloric regions, especially with deep craters or pockets, fixed or almost immovable on fluoroscopic study, with or without evidences of obstruction, and giving the appearance and often the physical evidence of the presence of a mass, should be suspected from the start as being complicated ulcers or malignancies. In such cases a careful ulcer régime should be promptly instituted, and if on rest, suitable diet and eradication of focal infections such a patient still shows the same roentgen findings at the end of three or four weeks, prompt surgical treatment is indicated. Even in severe cases the period of ulcer treatment is not to be considered a waste of time, as it is surprising how some cases, even with marked obstruction, will have almost cleared up during the interval. And in the cases in which operation must be performed later, the improvement in the patient's general condition, the correction of circulatory and nutritive deficiencies and the restoration of more normal tone to the gastric and intestinal musculature will do much to insure an uneventful postoperative course. These complicated cases are the ones which are usually described as intractable, as "failures of medical treatment," and surgeons love to present the removed specimens at meetings, asking how medical treatment could possibly have cured such ulcers. It is imperative that these cases should be recognized at the start, that patients be told that operation will probably be necessary and that the treatment being recommended will encourage healing, if this is possible, and will assure a successful operation if this is required later. In order to be certain that no other complications are being overlooked it is necessary, before instituting treatment in any case of ulcer, that not only a complete gastrointestinal study be carried out, but that any pathological conditions in the biliary tract, pancreas, urogenital organs, respiratory tract

and cardiovascular system be searched for and properly treated. It is only by painstaking care that patients with ulcers can be successfully treated.

SUMMARY

1. Peptic ulcer symptoms may occur without demonstrable ulceration or may persist after healing of ulcer.

2. Persistent ulcer symptoms may be caused by gastric carcinoma, tuberculosis or syphilis.

3. Persistent ulcer symptoms may be caused by successive ulcers at short intervals, new ulcers in slightly different locations being recognizable upon study.

4. Persistent ulcer symptoms may be caused by complications of the ulcer or complications other than in the ulcer itself, many requiring operative interference.

5. Allergy may cause repeated ulcers, may prevent healing or may produce symptoms simulating ulcer.

6. Inadequate or improper treatment may prevent healing and thus prolong symptoms.

7. The truly intractable peptic ulcer is a complicated ulcer, one prevented from healing by scarring, walled-off perforation, adhesions, deformities or obstruction, and should be recognized as a probable surgical case at the time of the initial study.

8. Operation should not be performed in any case until careful and repeated studies have revealed true persistence of an ulcer or permanent deformity resulting therefrom.

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Original Articles

IMMEDIATE COMPLICATIONS OF OPERATIONS FOR ACQUIRED CATARACT*†

CERTAIN COMPLICATIONS AFFECTING THE ANTERIOR AND POSTERIOR SEGMENTS OF THE EYEBALL

CONRAD BERENS, M.D. AND DONALD BOGART, M.D.

NEW YORK, NEW YORK

PART I—ANTERIOR SEGMENTS

THE great importance of preventing complications of cataract extraction in relation to the prevention of blindness is well known and has been a stimulus for this study. The first steps in the prevention of these complications are a thorough preoperative study of the patient and the treatment of focal infections as well as other general diseases. Because of the more universal adoption of the intracapsular method and its more general use by young surgeons in training, we believed that a study of the immediate complications of cataract extractions performed during a two-year period at the New York Eye and Ear Infirmary and a careful review of the literature might furnish valuable information. A total of 1,004 clinic patients were operated upon for acquired cataract by surgeons, assistant surgeons and house surgeons. Of this number 302 were intracapsular extractions and 702 were extracapsular extractions. (Table 1.) Mature senile, immature senile, hypermature, complicated, congenital, cortical, posterior cortical, nuclear, perinuclear, cataracta nigra, coerulean, diabetic, traumatic, posterior polar and anterior polar cataracts are included in this series.

It is interesting to note that 50 per cent of the extracapsular extractions were performed after preliminary iridectomy. This would seem to indicate that extraction with preliminary iridectomy is still considered by some surgeons the safest operation and is especially desirable in the presence of complications. This finding

TABLE I
TYPES OF OPERATION PERFORMED IN 1,004 CATARACT OPERATIONS

Operation	Intra-capsular	Extra-capsular
Extraction after preliminary iridectomy	118 (39%)	351 (50%)
Combined	176	341
Simple	7	10
Extraction after trephine	1	
Total	302	702

coincides with the consensus of opinion of the surgeons at the International Congress of Ophthalmology in Washington in 1922.

The average age of the patients upon whom intracapsular extraction was performed was sixty-five, although the ages ranged from twenty-seven to ninety years. Van Lint[1] employs the intracapsular method in patients over sixty years of age. However, many surgeons prefer to use this method on the majority of patients over fifty years of age. In the extracapsular

series, the average age was sixty-two, although the ages ranged from twenty-two to eighty-five years.

The immediate complications of the intracapsular and extracapsular extractions occurring in the 1,004 patients are tabulated in Table II. The results are expressed in terms of final corrected vision. The fact that many of the patients did not return or were unable to be contacted following their discharge from the hospital is a challenge to the social service department of the hospital. Unfortunately, this situation is not limited to one hospital.[2–5] Although some patients may not have

TABLE II

COMPARISON OF COMPLICATIONS IN INTRACAPSULAR AND EXTRACAPSULAR CATARACT EXTRACTIONS IN 1,004 PATIENTS

Complications	Intra-capsular (302 Cases)	Extra-capsular (702 Cases)
Loss of vitreous	30 (9.9%)	63 (9.%)
Prolapsed vitreous	1	2
Hemorrhage in anterior chamber	12 (4%)	10 (1.4%)
Expulsive hemorrhage	2 (0.7%)	3 (0.43%)
Dislocated lens	1	1
Loop extractions	4 (1.4%)	34 (5%)
Collapse of cornea	1	1
Prolapse of iris and ciliary body	1	0
Detachment of choroid	1	0
Capsule remains in anterior chamber	0	1
Total	53 (17.5%)	115 (16.4%)

returned because of illness or could not be located because of incorrect or fictitious addresses, some clinic patients apparently believe that an improved visual field and perception of light is all that can be expected following cataract extraction and therefore never return to be examined for cataract lenses.

Discussion of Table II. Among the intracapsular extractions, loss of vitreous was the most frequent complication, occurring in 9.9 per cent of the 302 cases. This complication was also most frequently observed in the extracapsular cases; the

percentage being 9. However, it must be remembered that the number of cases in the extracapsular series was considerably larger than that in the intracapsular series. Moreover, the majority of the extracapsular extractions were performed for complicated cataract. This would seem to suggest that loss of vitreous in the hands of the average ophthalmic surgeon is more likely to occur with the intracapsular than with the extracapsular method. The fact that the incidence of vitreous prolapse is slightly greater is offset largely by the freedom from postoperative endophthalmitis probably phacogenetic[6] or phacoanaphylactic[7] which was previously reported.[8]

The lens was extracted by means of a loop in thirty-four (5 per cent) of the extracapsular cases while this procedure was only necessary in four (1.4 per cent) of the intracapsular cases.

Hemorrhage occurred in twelve (4 per cent) of the intracapsular extractions and in ten (1.4 per cent) of the extracapsular extractions.

The fact that the incidence of expulsive hemorrhage was higher after the intracapsular operation possibly suggests the greater danger of this method.

The other complications, which were observed, occurred only in a few cases but the percentage of incidence was approximately the same following both procedures.

The complications occurring in the posterior portions of the eyeball not included in the anterior segment will be discussed in a later communication.

I. COMPLICATIONS ASSOCIATED WITH THE INCISION

A. Improper Introduction of the Graefe Knife. If care is not exercised in placing the cutting edge of the knife upward, introduction of the Graefe knife with the sharp edge of the blade downward is a fairly common mistake. If this error is noted before the counterpuncture is made, it is advisable to remove the knife and wait for the restoration of the anterior chamber. If the malposition of the knife is not noted

until the counterpuncture has been made, it is usually better to remove the knife and dissect a small conjunctival flap downward,
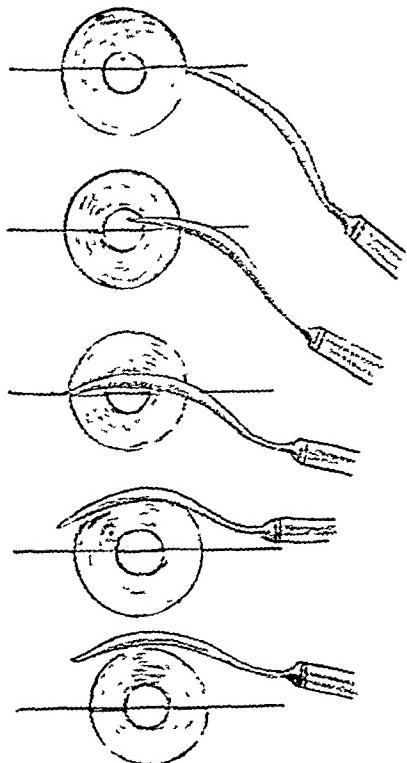
FIG. 1. Cataract incision with Jones-Scimiter knife.

completing the incision with special sclerotomy scissors.[9] If the knife is reversed in the wound, the aqueous is usually lost. Moreover, the anterior chamber will be so shallow that the iris may be injured while attempting to complete the section, unless the incision is extremely high in the cornea or an iridectomy has been performed. We prefer to complete the section with scleral scissors rather than wait several days, as is suggested by some authors. Improper introduction of the knife, especially at the counterpuncture may be caused by dilatation of the pupil. This may be prevented by the use of butyn or pontocain as a local anesthetic.

Introduction of the knife reversed in making a section is not nearly so frequent or dangerous as placing the point of introduction of the knife or the counterpuncture too far posteriorly, nor as inconvenient as a

section too far forward which often splits the cornea leaving a posterior corneal shelf. Inexperienced surgeons attempt all too often to make a large section even with a dilated pupil. It is better to follow the general rule that in making an upward section the back of the knife be level with the pupillary margin in passing across the anterior chamber.

II. COMPLICATIONS ASSOCIATED WITH THE IRIS

A. *Injury to the Iris.* If the point of the knife in entering the anterior chamber engages the iris, it should be directed further forward. However, if iridodialysis is being produced, withdrawal of the knife may be necessary until the anterior chamber has reformed. Bulging of the iris in front of the knife as the counterpuncture is made may be caused by loss of aqueous or a shallow chamber. The curved cataract knife of Paton[10] or the scimiter-shaped knife of Jones (Fig. 1) should be employed in the presence of a shallow chamber. A complete section can be made with little pain provided anesthesia has been carefully induced. (At times, a complete iridectomy may be performed with the Graefe knife. If a bridge of iris is left, this may be cut after grasping it with a blunt Tyrrell hook or with iris forceps or may be excised after the lens is expressed.) If the anterior chamber is unusually shallow, we prefer to make the section with a hollow ground keratome[11] or high in the cornea with a curved cataract[10] or glaucoma knife enlarging the incision with scleral scissors.

B. *Incomplete Iridectomy and Iridodialysis. Cause:* If the iris is not completely anesthetized when it is grasped with iris forceps or when withdrawal is attempted, the pain experienced by the patient may cause a sudden movement of the eyeball. One of us has seen a patient in whom complete aniridia was produced. In several cases of this group extensive iridodialysis was observed.

Prevention. To guard against incomplete iridectomy, iridodialysis and trau-

matic cataract, anesthetize the iris well. If cocaine is used, wait until dilatation of the iris occurs; warn the patient that he may experience slight pain and not to move. Moreover, the iris scissors should be open and in position to cut the iris immediately. In a congested eye the subconjunctival injection of a solution of cocaine 1½ per cent with epinephrine, when allowed five minutes for absorption, will prevent the pain in pulling on an iris with iris forceps. A rigid iris may contraindicate intracapsular extraction.

C. *Tendency for the Iris to Prolapse. Incidence:* Tendency for the iris to prolapse occurred in a large number of cases. This complication requires immediate treatment even though the wound is to be sutured.

Treatment. We have made it a rule never to perform simple extraction but always to excise, at least, a small piece of the peripheral iris. If one peripheral iridectomy does not prevent the tendency to immediate prolapse, a second peripheral iridectomy may be performed. However, if the sphincter is known to be weak or the iris is atrophic, it is wise to perform complete iridectomy. According to Bulson[12] the combined operation and a large conjunctival flap are the best measures to prevent iris prolapse.

D. *Prolapse of Iris and Ciliary Body.* This complication is usually considered as a postoperative complication but in one intracapsular operation, the patient complained of severe pain in the eye operated upon shortly after leaving the operating room. Upon inspection of the wound, it was found that the iris and ciliary body had prolapsed through the wound. Following iridectomy a conjunctival flap was brought down to cover the area.

E. *Complete Removal of the Iris.* Among the more unusual complications associated with cataract operations is the complete removal of the iris during an attempted preliminary iridectomy.[13] One of us (C. B.) observed a patient in whom the iris was completely removed but extraction was successfully performed. Hemorrhage is usu-

ally profuse and following the operation deeply tinted lenses should be worn to protect the eyes from glare.

III. COMPLICATIONS ASSOCIATED WITH THE LENS

A. *Difficulty in Expressing the Lens.* Although pressure and counterpressure should cause the lens to present in the wound, the following factors may interfere:

1. *Small section:* If the nucleus is small and the cortex is soft, the lens may be extracted by traction with capsule forceps or by carefully passing a spoon in back of the lens while making counterpressure from below. However, striate keratitis may result. If the lens is large and hard, the incision should be enlarged with scleral scissors. One blade of the probe-pointed scleral scissors is passed between the cornea and the iris into the anterior chamber pressing the external blade slightly backward toward the sclera in order to bevel the incision. Too large an incision favors vitreous prolapse and also incarceration or prolapse of the iris in the wound. However, it is usually preferable to have too large rather than too small an incision.

2. *Insufficient opening in the anterior capsule:* If the incision in the lens capsule is not sufficiently large, a cystitome should be used in attempting to make a broad incision in the capsule at the upper margin of the lens. If the capsule is difficult to open, it is usually better to attempt to extract the lens in capsule.

3. *Interference by scleral lip of the wound:* The upper margin of the lens may be caught by the scleral lip of the wound. This is likely to occur if the lens is subluxated before or during the operation or pressure with the expressor is improperly applied. Dislocation of the lens is best accomplished by pressure directed backward and downward at the limbus, not moving the expressor until the lens ceases to move forward and upward. The lens should be pushed gently downward with a spatula and pressure reapplied to the lower margin of the cornea while holding the scleral lip of the

wound down. If this procedure fails, pass a spoon carefully behind the lens while making gentle counterpressure from below. No
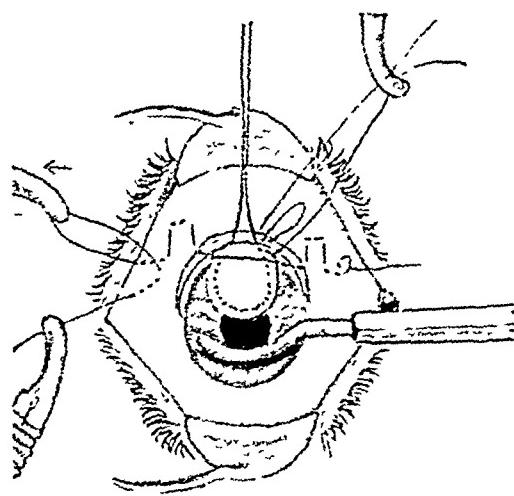
FIG. 2. Lens extraction with loop and expressor as wound is closed by traction on the sutures.

vitreous need usually be lost by following this procedure.

4. *Low Intra-ocular pressure:* If the retrobulbar injection is given too long before operation, low intra-ocular pressure may interfere with the extraction.

B. *Dislocation of the Lens.* Incidence: The lens was completely dislocated in one case in each series of extractions. The lens was extracted with a loop in thirty-four (5 per cent) of the 702 extracapsular extractions and in four (1.4 per cent) of the 302 intracapsular extractions. The visual results are shown in Table III.

Discussion of Table III. The use of a loop seems to be a dangerous procedure in the hands of the average surgeon. This complication was more serious in the extracapsular operations. Moreover, four patients of this group did not obtain useful vision. It was necessary to extract a greater number of lenses with a loop in the extracapsular series, and in many cases the final visual acuity was markedly subnormal. However, in evaluating the two methods of operation it must be remembered that in the extracapsular series a majority of the cases had complications preoperatively.

Cause of Dislocation of the Lens. In some cases, the hyaloid of the vitreous is ruptured by too much pressure with the fixation forceps and some vitreous will escape. The lens instead of entering the wound tends to be dislocated backward into the vitreous. Complete dislocation is caused by too much pressure or traction in making the discission. This is especially true when

TABLE III
CORRECTED VISUAL ACUITY IN EXTRACTIONS PERFORMED WITH A LOOP

Final Vision	Intra-capsular	Extra-capsular
$20/20$		2
$20/30$		2
$20/40$	2	5
$20/50$		1
$20/70$		3
$20/100$		4
$20/200$	1	1
$30/200$		1
Fingers		1
$3/200$	1	1
Light projection		1
No improvement		11
Eye lost		1
Not recorded	1	
Total	4 (1.4%)	34 (5%)

the capsule is tough or excessive pressure, improperly applied, is exerted against the eyeball when expressing the lens, particularly when the section is too small. In some cases, the lens may sink into the vitreous. This is a serious complication. Woodruff[14] believes that it is more likely to occur with the Barraquer suction operation.

Treatment. As soon as the malposition of the lens is noted, a thin spoon or wire loop should be passed gently in back of the lens keeping as close to the posterior capsule as possible, while making very slight counterpressure below with a strabismus hook or lens expressor. (Fig. 2.) The lens should be removed as quickly as possible and the wound closed with sutures. If the lens is completely dislocated, the use of an ultraviolet lamp[15] is of value in locating the

lens in facilitating its extraction with a wire loop, preferably one with teeth.

C. *Ruptured Capsule and Retained Cortex. Incidence:* The capsule was ruptured in seventy-one cases (7.1 per cent) of the 1,000 cataract extractions reported by Bothman.[16] In an analysis of the 1,343 intracapsular cataract extractions made by Greenwood and Grossman[17] the capsule was ruptured in approximately 5 per cent of the cases. In our series of intracapsular extractions the capsule was ruptured in 119 cases.

Cause. According to Walker[18] a ruptured capsule is usually due to the resistance of the zonular ligaments in approximately 10 per cent of the cases. Too large a bite of the capsule has seemed to be an important factor in causing rupture in some of our cases and this fault has been automatically controlled by the construction of several capsule forceps.[19,20,21] Where the forceps is applied is another important point in preventing this complication.

Walker[18] found that applying forceps to the anterior and posterior surface of the lens, as advised by Verhoeff, caused the capsule to rupture more frequently than when he applied his capsule forceps to the anterior surface alone near the equator where the capsule is thick.

Prevention. The frequency of this complication may be diminished by employing one of the following methods: subluxation of the lens followed by expression (Knapp); expression combined with traction (Elschnig); phacoerisis (Barraquer) and the suction method (Fisher).[22] In cases in which a weak or tense capsule is suspected a complete iridectomy should be performed.

Treatment. The Hildreth lamp is of great value in washing out all of the remaining soft lens, a procedure we do not fear when performed in the manner depicted in Figure 3. Close the wound with scleroconjunctival sutures, place the irrigating tip in one angle of the wound and a grooved spatula in the other angle and wash the anterior chamber thoroughly.

D. *Incomplete Removal of the Capsule of the Lens.* In one case of extracapsular extraction the anterior lens capsule was
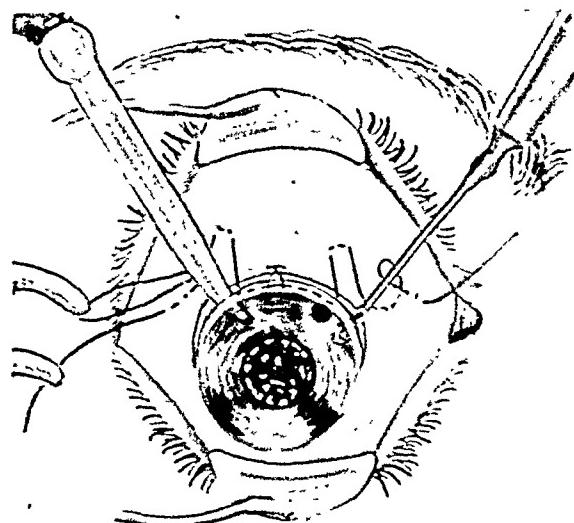
FIG. 3. Before removing soft lens matter close the wound with scleroconjunctival sutures, place the irrigating tip in one angle and a grooved spatula in the other angle.

retained following the delivery of the lens. In this case vision was reduced to "fingers" prior to discission. Usually the capsule should be removed from the eye before the operation is completed. Nugent[23] recommends the use of a carbon-arc light with a uviol or blue-glass filter. After the wound is partially sutured the cornea should be raised slightly with clot forceps in one hand and the capsule extracted with the capsule forceps in the other hand.

IV. COMPLICATIONS ASSOCIATED WITH THE CORNEA

A. *Gaping of the Corneal Wound with Tendency to Iris Prolapse.* After the section is made, the upper part of the cornea is pushed forward by iris and vitreous in approximately 25 per cent of eyes. This is usually the result of hypertension in the vitreous. A horizontally directed crease in the cornea may form because of the high tension within the vitreous or the pressure of a subchoroidal hemorrhage and the vitreous is likely to be lost if intracapsular extraction is attempted. Therefore, intracapsular extraction may produce less favorable results in this type of eye.

B. Collapse and Depression of the Cornea.
Incidence: Collapse of the cornea occurred in one patient upon whom intracapsular extraction was performed and in one of the extracapsular extractions. The final vision was $20/50$ and $20/30$, respectively. According to Green[24] after the section is made the cornea is seen to be depressed in 60 per cent of the eyes.

Cause. If the cornea is inelastic when the intra-ocular pressure is lowered, it may collapse, especially when cocaine is employed. However, this is of no consequence, as it usually indicates lowered vitreous pressure and less danger from escape of vitreous. Depression of the cornea is one sign which indicates that the case is probably favorable for intracapsular extraction but subluxation of the lens should be excluded.

V. COMPLICATIONS ASSOCIATED WITH THE ANTERIOR CHAMBER

When a shallow anterior chamber is present, Gailey[25] first makes a Kuhnt flap, then a small section which is enlarged with scissors and extracts the lens by the capsulotomy method. We have injected half strength physiologic saline solution into the anterior chamber to deepen it or use a curved cataract knife.[10]

An eye with a shallow anterior chamber may have a slightly increased tension. Gailey[25] advocates a decompression operation first or a capsulotomy operation with a broad deep iridectomy. If the shallow chamber is associated with glaucoma, we dissect a conjunctival flap, introduce a keratome into the anterior chamber, introduce a running suture[26] with episcleral bites and then enlarge the wound with scleral scissors.[9] We prefer as small an iridectomy as possible in cataract extraction.

Needling of the posterior capsule immediately after cataract extraction should be avoided because this procedure permits a herniation of the vitreous body into the anterior chamber.

When premature loss of aqueous from the anterior chamber occurs, Gailey ash

successfully filled the anterior chamber with the knife blade still in position by having the assistant apply the tip of the irrigator to the flat surface of the blade.

SUMMARY AND CONCLUSIONS TO PART I

1. The prevention of immediate complications following cataract extraction is important if unnecessary blindness is to be eliminated. A thorough preoperative study of patients with cataract and the treatment of focal infections, as well as other general diseases, are essential in order to eliminate some complications following the extraction of cataract.

2. A study of 1,004 intracapsular and extracapsular cataract extractions apparently demonstrates that the percentage of immediate operative complications is approximately the same following either procedure.

3. Cataract extraction after preliminary iridectomy apparently is still considered the safest operation by some ophthalmic surgeons, especially if complications are present preoperatively.

4. The average age of the patients included in the intracapsular group was sixty-five years and in the extracapsular group sixty-two years.

5. In this study, loss of vitreous, hemorrhage and the necessity of extraction by means of a loop were the most common immediate complications in cataract extraction. Loss of vitreous occurred in thirty cases (9.9 per cent) of the intracapsular group and in sixty-three cases (9 per cent) of the extracapsular group. Loss of vitreous apparently is a more frequent complication of intracapsular extraction than of extracapsular extraction even though intracapsular extraction is usually avoided in the presence of complications. However, comparative freedom from inflammatory postoperative complications when the intracapsular method is used must be considered in the final evaluation of the methods. Hemorrhage occurred in twelve (4 per cent) of the intracapsular group and in ten (1.4 per cent) of the extracapsular

group. Contrary to expectation, the incidence of hemorrhage into the anterior chamber was markedly different in the intracapsular and extracapsular methods, and we have no logical explanation of this fact. In this series of cases the lenses were extracted by means of a loop in thirty-four of the 702 extracapsular extractions and in only four of the 302 intracapsular operations. The fact that in the extracapsular series a majority of the cases had complications preoperatively must be considered. The other complications occurred in only a few cases of both groups of operations.

PART II—POSTERIOR SEGMENT

In the preceding discussion the general aspects of immediate complications of cataract extraction and the specific complications affecting the anterior segment of the eyeball were considered. This study is devoted to the general aspects of immediate complications of cataract extraction and especially to those affecting the structures of the posterior segment of the eyeball.

VI. COMPLICATIONS ASSOCIATED WITH VITREOUS

A. Loss of Vitreous. Loss of vitreous is undoubtedly the most common and important immediate complication of cataract extraction.

Incidence. Loss of vitreous occurred in thirty (9.9 per cent) cases of the 302 intracapsular extractions, and in sixty-three (9 per cent) of the 702 extracapsular extractions. The amount of loss varied from a minim or two to almost the entire vitreous body. The end results in terms of visual acuity are shown in Table IV. Results obtained by other authors are shown in Table V. According to Nugent[27] loss of vitreous occurs rarely in extractions by the traction method or when traction is combined with gentle expression.

Discussion of Tables IV and V. Loss of vitreous seems to occur more frequently in intracapsular than in extracapsular operations whether the operation is performed by

the average ophthalmic surgeon or by the most experienced and dextrous surgeons.[28,30] A point to be considered in the final evaluation of the two methods is the

TABLE IV

THE RESULT OF LOSS OF VITREOUS IN TERMS OF CORRECTED VISION

Final Vision or Result	Intra-capsular	Extra-capsular
20/20	2	4
20/30	4	6
20/40	2	7
20/50	3	3
20/70	4	6
20/100	2	7
20/200	4	4
30/200		1
Fingers		1
Light perception		1
Atrophy of eyeball		1
Eye lost and ennucleated	2	
Vision not recorded	7	22
Total....	30 (9 9%)	63 (9 %)

fact that the intracapsular method is often avoided in complicated cases. Therefore, the vitreous loss might be even greater if this operation were attempted in complicated cases.

TABLE V

LOSS OF VITREOUS

Author	Total Number of Cases	Loss of Vitreous Occurred in	Type of Operation
Parker[5]	450		
	150	3 (2%)	Combined
	150	5 (3 3%)	Simple
	150	9 (6%)	Knapp-Torok
Townes[4]	~3	6 (8 2%)	Intracapsular
Greenwood and Grossmann[21]	1,343	83 (6 2%)	Verhoeff / Intracapsular
de Grosz[20]	15,050	3~6 (2 5%) (1%) (4%)	Extracapsular / Intracapsular
Berens and Bogart	~02	63 (0%)	Extracapsular
Knapp[3]	302	30 (9 0%)	Intracapsular
Bothom[22]	500	42 (8 4%)	Intracapsular
	1,000	45 (4 5%)	Indian
Total	10,420	662	

Cause. The delicate hyaloid membrane of the vitreous is the only barrier to escape of the intra-ocular contents, especially after the lens has been removed. Intra-ocular pressure, which is often augmented by

pressure of the eyelids and squeezing on the part of the patient or the development of a subchoroidal hemorrhage, may rupture the
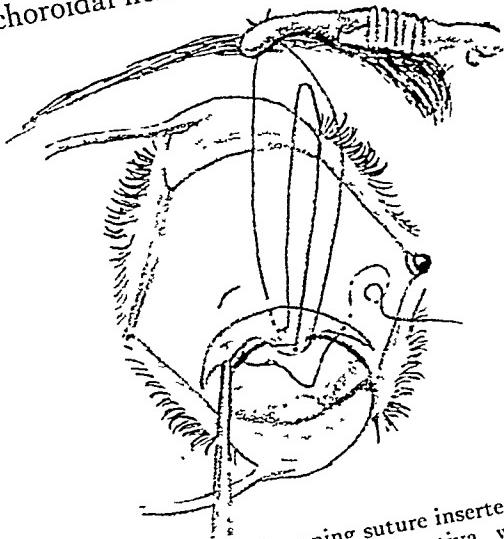
FIG. 4. An untied running suture inserted in the episcleral tissue and conjunctiva which is tightened as the lens is expressed. A centrally placed conjunctival episcleral suture is also employed.

hyaloid membrane. Contraction of the extra-ocular muscles, which is a real menace in some cases, may be difficult to avoid. This condition is augmented by excessive pressure against the eyeball when the section is made, especially if the pressure is exerted at the insertion of the medial rectus muscle. Pressure must be greater if the knife is not sharp and vitreous may even appear as the section is made.

The hyaloid membrane may also be ruptured in attempting to rupture the zonule with capsule forceps or to incise the capsule with the cystitome, especially if the capsule is tough or if the patients make a rapid movement of the eyeball. We believe the iris repositor is responsible for rupture of the hyaloid in some cases. Therefore, this instrument should be used with great care and preferably after the wound is partially closed by sutures.

Prevention and Treatment. Gentle, dextrous manipulation of instruments and the avoidance of pressure on the eyeball with fixation forceps or the speculum, especially during the expression of the lens, will do much to prevent loss of vitreous. If the

vitreous tends to prolapse or actually prolapses before extraction, elevate the speculum immediately, introduce a loop or thin spoon, back of the posterior capsule, remove the lens and close the wound. If the vitreous appears after the lens is extracted raise the speculum and close the wound with a suture. If the vitreous is fluid, it may escape as soon as the incision is made. Gifford[34] reported a case in which so much fluid vitreous escaped upon incision that he stopped the operation and later treated the cataract by several needlings. Useful vision was maintained for five years.

We agree with Dunphy[35] that loss of vitreous would occur much less frequently if every cataractous eye were properly anesthetized at the time of the operation by means of the Van Lint eyelid injection, combined with either a deep orbital or subconjunctival injection.

One of us has long advocated the insertion of an untied suture early in the operation[36,37] which is now placed in the episcleral tissue[38] as well as the conjunctiva and is tightened as the lens is expressed. (Fig. 4.)

VII. HEMORRHAGE

A. Hemorrhage into the Anterior Chamber. Incidence: Hemorrhage at the time of the operation occurred in twelve cases (4 per cent) of the intracapsular series and in ten cases (1.4 per cent) of the extracapsular series. In the other cases bleeding occurred principally from the scleral vessels or those of the iris. The visual results are shown in Table VI.

Discussion of Table VI. There was marked difference in the incidence of hemorrhage into the anterior chamber in the intracapsular and extracapsular methods. It is impossible to explain why the incidence was greater in the intracapsular group as postoperative complications were less in this series of cases.

Cause. Hemorrhage into the anterior chamber may follow conjunctival or scleral bleeding. However, it is more likely to occur from the iris, especially if the pa-

tient's vessels are sclerotic or if there is a disinsertion of the iris. Sudden diminution of increased intra-ocular tension and general hypertension also may be possible causes.

In irides with prominent new vessels and in arteriosclerotic individuals, free bleeding is commonly observed; therefore, too much manipulation, unnecessary cutting or too

TABLE VI

VISUAL RESULT IN CASES WITH EXCESSIVE HEMORRHAGE INTO ANTERIOR CHAMBER

Final Vision	Intra-capsular	Extra-capsular
20/20	1	
20/30	2	2
20/40	2	
20/70	1	1
20/200	1	1
5/200	..	1
3/200	..	1
Fingers	..	2
Shadows	..	1
Eye lost	3	
Not recorded	2	1
Total	12 (4%)	10 (1.4%)

strong a pull placed upon irides by atropine or eserine should be avoided.

Prevention. Nugent[27] advises the instillation of adrenalin-chloride preoperatively as an aid in the prevention of hemorrhages during the operation. However, the risk of postoperative hemorrhage has been said to be greater if adrenalin is used. However, Jensen[39] made a study of eighty cases of cataract extraction in which adrenalin was used in every other case. A comparison of the results obtained showed that the percentage of hemorrhage into the anterior chamber was about the same. However, in the cases in which adrenalin was not employed the majority of hemorrhages occurred at operation, while following the use of adrenalin they occurred within the first forty-eight hours after operation. To avoid retrobulbar hemorrhages Gailey[40] suggests the use of Harvey Cushing's technic in brain surgery, that is, to inject very slowly ahead of the advance of the tip of

the needle. Coagulation and bleeding time should be studied preoperatively and abnormalities corrected. In cases of arteriosclerosis, Wright[41] recommends an injection of 1½ gr. of calcium in 10 cc. of distilled water intravenously. However, we prefer to use calcium gluconate.

Treatment. In conjunctival or scleral bleeding the anterior chamber should be washed out with half strength physiologic saline solution. If the hemorrhage occurs from the iris, it is usually advisable to wash out the anterior chamber several times before performing capsulectomy or capsulotomy or attempting to remove the lens in capsule. Abramowicz[42] advises the introduction of air into the anterior chamber in order to remove blood and produce a clear view of the anterior lens surface, thus facilitating the capsulotomy or the application of forceps for removal of the lens.

If after the lens is extracted bleeding occurs, it may be washed out or removed with clot forceps, for if much soft lens matter remains it usually absorbs more quickly and completely if no blood remains. If a vessel in the wound bleeds persistently, the electrocautery or trichloracetic acid may be applied.

It has been stated that the secondary membrane is likely to be more dense in the presence of hemorrhages. This seemed to be true in one patient who had dinitrocresol cataracts. One year after operation the vision in the right eye, in which no hemorrhage had occurred, was 20/15 and in the left eye in which a hemorrhage had filled the anterior chamber, the vision was 20/20 and the secondary membrane was much more dense.

B. Choroidal and Expulsive Hemorrhage. Choroidal and expulsive hemorrhages are the most dangerous of all complications during cataract extraction.

Incidence. Expulsive hemorrhage occurred in two cases of the intracapsular series and in three of the extracapsular cases. In the three cases in the extracapsular series the eyes were eviscerated while

in the intracapsular group the eye was enucleated in one patient and in the other, the eye was eviscerated.

Cause. Increased intra-ocular tension probably is an important predisposing cause of choroidal hemorrhages. In a study of 2,200 cases of cataract extraction, Nugent[27] reports choroidal hemorrhages in seventeen cases (sixteen patients, 5 per cent). The average intra-ocular tension for the seventeen cases was 43 mm. of mercury (Bailliart) and the blood pressure was normal.

Prevention. An attempt should be made to reduce intra-ocular pressure preoperatively. If this fails, use a retrobulbar injection ½ to 1 cc. of 2 per cent solution of procain with 3 m. of a 1:1000 solution of epinephrine hydrochloride. If pressure remains elevated, perform posterior sclerotomy. Lowering the general blood pressure by the preoperative removal of several hundred cubic centimeters of blood and the injection of the ciliary ganglion are two precautions which are believed to aid in preventing this serious complication. However, Gifford[43] does not approve of withdrawing blood since it is generally followed by a vasomotor reaction which immediately sends more blood to the peripheral circulation. Blood pressure may often be reduced by preliminary medical care and more effectively by several days of rest in bed before the operation.

In cases with hyperpiesis, preventive measures consist in eliminating all unnecessary pressure and traumatism. The lens should be expressed slowly so that intra-ocular pressure is not reduced too suddenly.

Treatment. Hemorrhage usually appears after the expression of the lens. The eyelids should be closed immediately, the wound sutured and a light compressing dressing applied. The patient should rest with his head and torso as nearly erect as possible. Even though the intra-ocular contents escape, it is sometimes better to postpone enucleation because of the psychologic effect upon the patient.

Vail[44] has reported two cases of subchoroidal expulsive hemorrhage, in which posterior sclerotomy as suggested and used successfully in one case by Verhoeff[45] saved the eyes and prevented complete deterioration of vision. In both cases an incision with a Graefe knife in the temporal side of the eyeball resulted in the appearance of bright red blood and the subsidence of pain within a relatively short time. This procedure has been used by one of us (C. B.) with retention of the eye and resulting vision of hand movements.

C. Detachment of the Choroid. Incidence: Detachment of the choroid occurred in only one case of the intracapsular group. Final vision was not recorded. Fuchs[46] gave the incidence of detachment of the choroid as 4.7 per cent of all extractions. Barkan[47] reported a large series of cataract extractions with detachment of the choroid occurring in approximately 4.5 per cent of the cases. Hagen[48] reported eleven detachments in a series of fifty consecutive cataract extractions, an incidence of 22 per cent. O'Brien[49] made a study of 140 consecutive cases of cataract extraction in which detachment of the choroid occurred in eighty-six cases (93 per cent).

According to O'Brien[49] detachment of the choroid occurs at operation in almost every case. It is impossible, however, to determine the exact incidence, since the fundus is not always visible as a result of blood, air or cortical material in the anterior chamber. In those cases in which the fundus can be seen immediately after the operation the detachment of the choroid, according to O'Brien, is almost invariably found.

Cause. Detachment of the choroid occurs usually in cases which present a shallow or empty anterior chamber, folds in Descemet's membrane and a soft eyeball. O'Brien[50] believes that this complication is usually caused by low intra-ocular pressure which produces congestion of the uveal vessels and rapid transudation of fluid from the choroidal vessels into the suprachoroidal lymph spaces. In a discussion of O'Brien's

paper, Reese[51] states that if the detachment were due to the lowered pressure of the eyeball and the relative increase in pressure of the thin-walled vascular channels of the choroid, a more frequent occurrence of choroidal detachment following operations for glaucoma would be expected. Wilder stated that detachments of the choroid occur after any operation in which the tension of the eye is suddenly reduced. We have seen almost complete detachment of the choroid following iridocorneosclerectomy with iridencleisis with complete spontaneous reattachment. According to Knapp, detachment of the choroid cannot be entirely due to reduction in the tension of the eyeball, and secondary contraction of the vitreous must be present in these cases. Verhoeff prefers to call it a compressibility of the vitreous, meaning the readiness with which fluid can be expressed from the vitreous and its volume thereby reduced. This explains why detachment does not always occur when intra-ocular pressure is reduced.

Treatment. As the condition heals spontaneously no special treatment seems to be indicated. According to Manes,[52] cases in which detachment of the choroid occurs, recover more quickly than those in which it does not occur. Manes, therefore, has attempted to produce this complication by gentle pressure on the inferior segment with a strabismus hook.

VIII. GLAUCOMA COMPLICATING EXTRACTION

In this study of 1,004 cases of cataract extraction, glaucoma was present preoperatively in nine (3 per cent) of the intracapsular series and in twenty-seven (3.9 per cent) of the extracapsular series. When glaucoma occurs postoperatively in cataract cases, changes in the anterior segment can usually be found, i.e., position of structures, cells in the aqueous and cicatricial tissue. In the intracapsular and extracapsular extractions loss of vitreous occurred in eighty-eight patients (9 per cent) who did not have glaucoma. Of the thirty-six cases in which glaucoma was present loss of

vitreous occurred in five (14 per cent). Four of these patients had extracapsular operations performed and one intracapsular extraction. Hemorrhage in the anterior chamber occurred in only one glaucomatous case (3 per cent), while the percentage of hemorrhages in the anterior chamber in the nonglaucomatous cases was 2.2 per cent. The postoperative visual results obtained in the intracapsular and extracapsular series are shown in Table VII.

TABLE VII
VISUAL RESULTS FOLLOWING CATARACT EXTRACTION COMPLICATED BY GLAUCOMA

Final Vision	Intra-capsular	Extra-capsular
$^{20}\!/_{20}$	..	1
$^{20}\!/_{30}$	..	2
$^{20}\!/_{40}$	1	2
$^{20}\!/_{70}$	..	1
$^{20}\!/_{100}$	..	3
$^{20}\!/_{200}$	..	1
$^{5}\!/_{200}$	..	1
$^{8}\!/_{200}$	..	1
Hand movements	2	2
Fingers.	..	2
Light projection	1	
Eye lost (tension 65)	1	
Vision not recorded	3	11
Not recorded in case of hypopyon	1	
Total	9 (3%)	27 (3.9%)

Discussion of Table VII. The visual results varied from $^{20}\!/_{20}$ to light perception. In addition one eye in the intracapsular group was lost. A comparison of the two procedures reveals that the visual results following extracapsular extraction were apparently better than those following the intracapsular method.

Extracapsular extraction is the operation of choice in the majority of cases, when the limits of normal tension of the eyeball are exceeded, allowance being made for the rigidity of the sclera (Friedenwald[53]). It is usually advisable to perform a preliminary iridectomy or iridocorneosclerectomy[54] if hypertension is not controlled by miotics, followed by extracapsular extraction several months later. The time for

operation depends upon the progress of the glaucoma as indicated by the visual field, tension and pupillary reactions. How long the increased pressure has been present and whether the onset of raised tension was sudden are important points to be considered because the eye can apparently adapt better to increased intra-ocular pressure that develops slowly. Before operation, arteriosclerosis with hyperpiesis should be treated.

A case is reported by Davis[55] in which intra-ocular tension was lowered from 60 to 0 during avertin anesthesia. Therefore, this method of anesthesia should be considered in highly nervous or apprehensive patients with glaucoma complicating cataract extraction. However, we have had considerable success in reducing tension preoperatively by means of a retrobulbar injection of procain (2 per cent) combined with a 1:1000 solution of adrenalin. If this fails, a posterior sclerotomy is performed, a large conjunctival flap is prepared and sutures partially introduced. A keratome incision is made so that pressure may be slowly reduced and the wound is enlarged with scleral scissors. "Evipal" intravenous anesthesia was used in one case of our series with good results.

IX. DIABETES COMPLICATING CATARACT EXTRACTION

Diabetes is another general complication which is frequently encountered. In the intracapsular series it was present pre-operatively in thirty-nine cases (13 per cent). In the extracapsular group, diabetes was a complication in 109 cases (16 per cent). (Table VIII.)

Vitreous was lost in eighty-three (9.9 per cent) of the patients who did not have diabetes, while in the diabetic patients vitreous was lost in ten (7 per cent). Hemorrhage in the anterior chamber occurred in four (3 per cent) of the 148 diabetic patients, while hemorrhage in the anterior chamber occurred in twenty-two (2.2 per cent) of the 1,004 patients.

Iris hemorrhage at the time of cutting the iris, and on the third or fourth post-operative day from iris or retinal vessels may be multiple and small in diabetics. Furthermore, there seems to be in debilitated individuals a great tendency to the development of low grade iritis which persists and may progress to iridocyclitis, especially if much trauma or any complications have occurred.

TABLE VIII

VISUAL RESULTS FOLLOWING CATARACT EXTRACTION IN DIABETIC PERSONS

Final Vision	Intra-capsular	Extra-capsular
20/15	1	
20/20	4	4
20/25	1	
20/30	4	9
20/40	12	25
20/50	4	9
20/70	5	15
20/100		3
20/200	3	12
Fingers		1
Hand movements		2
Not recorded	5	29
Total	39 (13%)	109 (16%)

Discussion of Table VIII. A comparison of the visual results obtained following the intracapsular and extracapsular methods in diabetic patients reveals that the results were approximately the same. It must be remembered, however, that the number of extracapsular cases was approximately four times as great as the number of intracapsular cases and that the intracapsular operation was often avoided in complicated cases.

Experience has shown that satisfactory results can be obtained following cataract extraction in diabetic patients if proper care is taken. According to Wilder[56] complete control of the glycosuria is not essential and the results of operation for cataract in diabetic patients are as good as the results in nondiabetic patients. Most authorities, however, still believe that complications are more frequent in diabetic patients than in nondiabetic patients. Fox[57] believes that diabetes is not the cause of most cases of cataract. Since cataract

seldom occurs in young persons with diabetes, it is assumed that senility is the greater factor. The conclusions are drawn by Waite[58] that senile and complicated cataracts occur with approximately equal frequency in diabetic and nondiabetic patients.

Wheeler[59] in a study of 2,123 extractions of cataract performed at the New York Eye and Ear Infirmary found that hemorrhages occurred in 28.94 per cent of the diabetic patients while the average incidence was only 5 per cent in cases of uncomplicated cataract. Ballantyne[60] noted that hemorrhages which occur in patients with diabetes are extremely slow in absorbing. Benedict[61] operates for cataract on chronic diabetic patients who have been prepared by one or two weeks' observation of diet with added protamine insulin. He has not seen repeated hyphemia with the new insulin preparation as he did with the old insulin. We agree that reduction of the sugar content of blood and urine to its minimum should be attempted by means of diet, but if hyperglycemia is not controlled by these methods, insulin should be administered.

In diabetic patients with ocular hemorrhages it has been found by Friedenwald and Gichner[62] that capillary fragility as tested by a blood pressure cuff at 100 mm. of mercury for three minutes is increased, whereas in diabetes with no ocular hemorrhages, capillary fragility is in general normal. Such increased capillary fragility is characteristic of scurvy, and the vitamin c metabolism of these patients was studied. In some instances an abnormality of the vitamin c balance was found but this is not regularly the case, and these authors do not now believe that vitamin c is concerned in this hemorrhagic tendency. The cause of the increased capillary fragility remains obscure.

SUMMARY TO PART II

1. Loss of vitreous apparently occurs more frequently in intracapsular extraction of cataract than in extracapsular.

2. There was a higher percentage of hemorrhages in the intracapsular group of cases.

3. Expulsive hemorrhage occurred in 0.7 per cent of the intracapsular series and in 0.43 per cent of the extracapsular series.

4. Although detachment of the choroid was observed in only one case (intracapsular extraction), certain surgeons believe that it occurs in almost all cases at the time of operation.

5. The visual results in cases in which glaucoma was present preoperatively were better following extracapsular extraction. A comparison of the percentage of hemorrhages in the anterior chamber occurring in the intracapsular and extracapsular series of cases and the percentage occurring in the glaucomatous cases revealed a slightly higher incidence in the glaucomatous patients. This was also true in regard to the amount of vitreous lost. In the glaucomatous cases loss of vitreous occurred in 3 per cent, while in the nonglaucomatous patients the percentage of cases in which vitreous was lost was 2.2 per cent.

6. Following intracapsular and extracapsular extraction of cataract in diabetic patients, the visual results and other complications were approximately the same as in cases uncomplicated by diabetes. Hemorrhage in the anterior chamber occurred in four (3 per cent) of the 148 cases of diabetes, while the percentage of hemorrhage in the anterior chamber in the 1,004 cases was 2.2 per cent. The preoperative administration of vitamin c and b seems to be rational therapy. Contrary to expectation vitreous was lost in only 7 per cent of the diabetic cases and in 9.2 per cent of the 1,004 cases.

7. Following is a summary of some of the points which should be considered in the prevention of immediate complications of cataract extraction: (a) Careful preoperative study of the patient and the administration of appropriate treatment. There were fewer postoperative inflammatory complications following the intracapsular operation and these statistics have been

reported. This fact must be considered in evaluating the two methods. (b) If tension is elevated preoperative reduction of intra-ocular pressure by miotics or operation followed by extracapsular extraction; if intervention is urgent posterior sclerotomy may have to be performed as a preliminary measure if avertin or a retrobulbar injection of procain and epinephrine hydrochloride, fails to lower tension. (c) Preoperative lowering of general blood pressure by rest and other means and if retinal blood pressure is known or believed to be elevated, lowering the intra-ocular pressure by injection of the ciliary ganglion at operation. (d) Extracapsular extraction in cases of increased tension within the vitreous. (e) Obtain complete anesthesia and akinesia of the eyelid and eyeball: eyelid and retrobulbar injections in all cases combined with a subconjunctival injection of procain. (f) Insure a perfect section well protected by properly introducing the Graefe knife and by obtaining a complete conjunctival flap. (g) Prevention of injury to the iris by complete anesthesia, withdrawing the knife if the point engages the iris and by making a small incision with a curved or scimiter-shaped cataract knife or hollow ground keratome if the anterior chamber is shallow; followed by enlargement of the wound. (h) Sutures which may be quickly tightened should be in placed before the lens is extracted and should be tied before the anterior chamber is irrigated or the iris respositor is used. (i) The incision should be large enough to prevent any undue pressure on the eyeball in expressing the lens. (j) Be sure to perform complete discission of the anterior capsule or if capsule forceps are used grasp the anterior capsule near the equator where it is thickest first below and then above with only a narrow bite. (k) Avoid excessive pressure with fixation forceps when making the incision. (l) Eliminate undue pressure and traumatism throughout the operation. (m) Prevent sudden movement of the eyeball by inserting a suture in the superior rectus after producing anesthesia with a subconjunctival injection of 2 per cent solution of procain. (n) Complete or peripheral iridectomy to prevent prolapse of the iris. (o) In diabetic patients control hyperglycemia by diet if possible so that the use of insulin may be discontinued for several weeks before operation. (p) In excessively nervous or irritable patients, consider the use of avertin or evipal anesthesia.

8. Finally, if this discussion stimulates renewed interest by ophthalmic surgeons in the causes of immediate complications of cataract extraction and more careful consideration of the means of prevention and methods of treatment, which may be employed, it will have served its purpose and should aid in reducing the amount of unnecessary postoperative blindness or lowered visual acuity.

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PREVENTION OF DISCOMFORT AND DISABILITY IN THE TREATMENT OF VARICOSE VEINS

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THE disturbing sequelae, such as pain, discomfort and disability often encountered in the treatment of varicose veins, have been a problem to the physician. To prevent these unpleasant complications, I have found it feasible to adopt the technical and precautionary measures herein outlined. It is unfortunate that many patients refuse treatment for their varicosities, because they have experienced a painful treatment or they have been forewarned by relatives, friends and even physicians about the unpleasant and hazardous nature of this treatment. Untreated varicose veins almost invariably lead to complications such as dermatitis, phlebitis and ulceration and are often the cause of untold suffering and financial hardship. If the patient is assured that treatment can be effected with minimum discomfort and optimum therapeutic and cosmetic results, he will be willing not only to undergo active treatment for the correction of complications, but also will be amenable to prophylactic treatment.

ACCEPTED METHODS OF TREATMENT

It is not within the scope of this article to discuss indications and contraindications to active treatment, the various tests to evaluate the venous circulation of the lower extremities or the technic of ligation. These are subjects which have been adequately presented in recent textbooks and medical journals. However, a short review of the modern method of varicose vein treatment is in order.

Present day treatment of varicose veins is based on the efficiency of the injection treatment alone and injection treatment

combined with surgical procedures. The latter procedure yields more satisfactory results at present because of the better understanding of the principles of ligation. From 1920 to 1930, as improved and safer irritant solutions became available, the sclerosing therapy for varicose veins was widely acclaimed as the perfect solution to the problem. Surgical measures declined and were considered antiquated. However, the inadequacy of injection treatment alone for all cases of varicosities soon became apparent to the great majority of physicians. Numerous reports appeared on the high incidence of recurrence of varicosities after sclerosing therapy alone had been used.

At present, division of the great saphenous vein at its junction, with resection of all important collaterals is considered indispensable in the treatment of varicosities in all cases in which incompetency of the saphenous system can be demonstrated. This method has greatly reduced the incidence and severity of recurring varicose veins. Adams[1] advocates high ligation in all cases of varicosities in which the valves are incompetent to the effects of any increase of intra-abdominal pressure such as that caused by coughing or straining, even though these valves may be competent to simple gravity effects. Although ligation is a very important part of the treatment, it is not sufficient in itself. Failure to complete the sclerosis will result in local varicosity at first, but sooner or later the ectasia will progress to more and more branches with possible involvement of communicating veins. Therefore, adequate postoperative injections of all remaining unsclerosed

varices are necessary to attain good end results.

Ligation is not indicated in all varicose conditions. Incipient varicosities and varices with no demonstrable backflow in the saphenous system should be treated by injection alone. A large proportion of patients, because of a nervous temperament, refuse ligation, but are willing to accept injection treatment alone. These patients should be given the benefit of sclerosing therapy, even though the results may be only transitory. The same patients realizing the value of treatment often discard their prejudice against surgical measures to obtain more permanent results. Regardless of the method of treatment, we cannot promise permanent freedom from varicose veins, especially in the presence of vulval or suprapubic varicosities; but we can assure our patients that they will avoid suffering and disability if they do not neglect their condition.

TECHNIC OF INJECTION TO PREVENT EXTRAVASATION AND SLOUGHING

Extravasation resulting in complications such as painful perivenous edema, induration and sloughing is almost without exception due to faulty technic. A large number of patients refuse treatment for fear of these unpleasant complications. It is my belief that this grave situation is avoidable. While the absence of serious allergic reactions in my patients may be due to fortuitous coincidence, I cannot attribute the absence of induration and sloughing during the past five years to good luck alone. I am quite certain that the following technical procedures have been instrumental in preventing extravasation and sloughing:

1. Avoidance of puncturing an indurated, pigmented, or eczematous area by starting the injection in healthy tissue.

2. Fixation of the vein to prevent its transfixion or its displacement by the needle. This is best done by exerting with the thumb an upward pressure on the overlying skin. After introduction of the needle into the vessel lumen, the vein is not likely to roll away from the needle upon release of an upward pressure, but such a situation is apt to occur after release of a downward pressure on the skin.

3. Introduction of the needle parallel to the longer axis of the varicosity and selecting from a cluster of varices the varix with the greatest diameter will also help to avoid transfixion of the vessel.

4. Avoiding transfixion of small invisible subcutaneous varicosities when approaching a large varix with the needle; these can be revealed by careful palpation of the area.

5. Insertion of the needle at about one-third of an inch from the vessel to avoid puncture of the skin over the varix. This is imperative when injecting superficial, intracutaneous, bluish varices covered by only a thin layer of atrophic skin. It is obvious that necrosis and sloughing will result from contact of an irritant solution with the weakened tissues surrounding the puncture. Injection into collapsed veins (empty vein technic) necessitates the introduction of the needle at a distance from the varicosity.

6. Avoidance of dislodging the needle while pressure is exerted on the plunger. This is best effected by firm but gentle pressure of the fingers supporting the syringe on the extremity. This precaution will anchor the needle within the vessel lumen and prevent transmission of the force exerted on the plunger to the needle.

7. Avoidance of overdistending the varix with sclerosing solution. Increased resistance to the introduction of solution with visible bulging of the injected varix is a warning signal to discontinue the injection.

The use of needles of small gauge (No. 25 or 26, ¾ to ⅝ inch long) will facilitate firm anchorage in the vessel lumen and prevent leakage of sclerosing solution into the surrounding tissues.

PREVENTION OF PAIN AND DISCOMFORT

In the treatment of varicose veins, it is necessary to eliminate pain and discomfort since they often result in disability. Toward this end the empty vein technic will be

found very helpful. In this type of therapy, the physician must obtain and retain the patient's confidence in order to assure continuance of the treatment. It is also important to keep the patient ambulatory and competent to pursue his usual activities during the course of treatment.

It is true that full vein injections will give maximum engorgement with ease of injection for the operator. This technic, however, will also result in maximum gross thrombus formation with the appearance of painful, hard, nodular masses and extensive edema in the perivenous tissues. The resulting pain and discomfort and the red indurations protruding in the form of unsightly strings or knots, often the cause of ambulatory limping, do not encourage the patient to continue treatment. The distress accompanying such massive thrombosis is frequently beyond the tolerance of the more sensitive patient and forces him to bed, thereby increasing the possibility of embolism. Our promise that treatment will be ambulatory is thus nullified. Large thrombosed veins are very slowly absorbed and are often the seat of recanalization. The avoidance of severe inflammatory changes in the perivenous tissues is also desirable to maintain these tissues in a fair state of integrity, should further treatment for possible recurrences be necessary. Even if the only advantage of the empty vein technic lay in the avoidance of pain and discomfort, it would seem sufficient reason to advocate it ardently.

However, there are other desirable advantages in employing the empty vein technic. Sclerosis by injection into empty veins will cause blocking of the varices by fusion of the opposing surfaces of the vessel and not by gross thrombosis. Direct contact of the intima with the chemical irritant, only slightly diluted by blood, produces a severe degree of irritation of the endothelium followed by an ample production of fibroblasts. The latter are instrumental in binding the opposing surfaces of the vessel firmly, as brought out by Al Akl.[2] Recanalization of such closed channels is less likely

since they undergo organization and absorption more readily. The difficulty of obliterating resistant varicosities and the hazard of closing so-called blood lakes are also greatly reduced by the use of empty vein injections.

The disfiguring nature of varices is embarrassing to most patients and often is the only factor prompting them to undergo treatment. Undoubtedly, the results following injections into empty veins are more gratifying from the standpoint of cosmetic appearance. Adequate compressive collapse, as will be brought out, is also essential to obtain better cosmetic results. Discoloration, so objectionable to many patients, is greatly reduced following empty vein injections.

The main objection to the employment of the empty vein technic lies in the theoretical rather than the actual possibility of sclerosing solution escaping through communicating veins into the deep venous circulation, with eventual damage to it. Since several authorities (Unger,[3] 1927; Sedwitz, Steinberg,[4] 1938) use large amounts of a rather strong irritant solution for the retrograde segmental injection, which really is an injection into empty veins, this objection cannot be substantiated (Pratt,[5] 1939, uses 20 to 60 cc. sodium ricineolate). Comparatively small amounts of sclerosing solution, $\frac{1}{4}$ to 3 cc. are required in the empty vein technic since dilution of the irritant by blood is reduced to a minimum.

For this reason, in my opinion, the use of the empty vein technic does not increase the hazard of allergic reaction from sensitivity to the injected drug. It is difficult to explain why I have not encountered any serious allergic manifestations up to the present time. This may be due either to the constant practice of employing several very small initial doses of any solution I choose to inject, or to fortunate coincidence. However, it appears that these favorable results are definitely related to the administration of small doses of solution with the empty vein technic. Thus, the sudden introduc-

tion into the general circulation of a massive dose which might precipitate an allergic reaction is avoided. In view of the above mentioned distinct advantages, I consider the empty vein technique not only the technic of choice, but in several instances to be cited later, the technic of necessity.

The technical difficulty of injecting collapsed varicosities is its only disadvantage. This can be inferred also from the chapters on technic in recent textbooks on the management of varicose veins. Ochsner-Mahorner[6] state in "Varicose Veins": "One may have his own variations in technic but will learn quickly that nothing brings the varicosities into prominence so promptly or so distinctly as having the patient stand." Riddle[7] writes in "Injection Treatment": "The author uses all three positions, but as a rule employs the standing position. The operator will find it very convenient if the patient stands upright on the examining table."

Several of the technical procedures that I have found very helpful in overcoming the difficulties of the empty vein technic are presented here. These should be of particular interest to the beginner to encourage him to adopt suitable technic and to develop the necessary skill. Methods of technic must be varied and individualized to suit the different veins in individual patients. The operator may employ suitable modifications such as the use of rubber tourniquets, digital manipulations to empty varicosities or placing the patient on an inclined cushion.

EMPTY VEIN TECHNIC

Initial injections are best made in isolated superficial veins of the leg, using small doses of sclerosing solution to avoid unpredictably severe reactions. Quite often one will find that only small amounts are necessary to produce clinical results, thereby avoiding pain and discomfort which would result from a larger dose. I consider a reaction satisfactory when the patient complains of little or no pain and

of only slight soreness on pressure over the occluded varix. The use of small initial amounts will help to avoid an acute flare-up of unrecognized latent phlebitis often associated with varicose veins as a result of the stagnating venous circulation. The degree of reaction to a small amount of sclerosing solution will indicate the state of vulnerability of the intima to the irritant and will help determine the optimal dosages for successive injections. These are gradually increased if no sign of sensitivity to the chemical irritant is observed and if larger doses are necessary to produce a desired sclerosis. Increased surface temperature at the site of varicosities is an important indication to proceed carefully with sclerosing treatment. Otherwise, a migrating phlebitic reaction in distant varicosities with its accompanying local and general discomfort may result. I have observed massive thrombosis of extensive varicosities in the leg or thigh following the injection of a large initial dose of sclerosing fluid in a distant vein segment. Adequate compressive support and cold applications will relieve pain and keep the patient ambulant in the event of a severe reaction.

INJECTION OF LARGE VARICOSITIES

The position of the patient is important for successful empty vein technic. When the patient is in the recumbent position, large varicosities rarely collapse to such a degree that injection into them is unsafe. Frequently, elevation of the extremity and stripping of blood is necessary to empty large varicosities. Blood can usually be aspirated freely from such varices. One may proceed carefully with the injection even when blood has not been freely aspirated if, after 1 or 2 m. of solution have been injected, one can ascertain by careful palpation the absence of any induration which would result from extravasated fluid. Adequate compression is of primary importance to maintain large varicosities in a collapsed and well supported state after injection. The irritation of the vein walls caused by compressive collapse may also be

an additional factor for effective sclerosis. For compression a flat sterile gauze pad (Zobec 2 × 2 inches) and adhesive tape, will guard against the possibility of unsupported thrombosis caused either by a retrograde flow of solution or by a possible

Fig. 1. A, extensive, tortuous varicosities in the kneefold impeding walking; B, after treatment. Ligation and subsequent injections resulted in cure. In the treatment of large sized varicose veins effective support is of primary importance for good immediate and end results.

$1\frac{1}{2}$ to 2 inches wide, is preferred. The adhesive strips should be sufficiently long to give effective compression and may encircle the entire leg. Care should be exercised to apply the adhesive with even pressure and to avoid extreme compression which might interfere with the deep circulation. In the presence of sensitivity to adhesive plaster, insertion of gauze strips between the adhesive and the skin is advisable. In certain cases, it is indicated to maintain support with the aid of an elastic bandage, such as the Ace bandage or with elastic adhesive strips.

It has been my experience that best cosmetic results are obtained not by confining support exclusively to the site of the injection but by supporting the uninjected proximal and distal varices as well. This

migrating phlebitic reaction and thereby will limit and often prevent possible massive thrombosis. The use of small strips of adhesive tape to secure a gauze pad covering the needle puncture is entirely inadequate. Firm support is a cardinal factor in effecting painless and good cosmetic results and, therefore, should be carefully considered by the physician. When adequate support is given to injected large varicosities, even the more sensitive patient remains ambulant during treatment with few or no complaints. (Fig. 1.) Firm support is especially desirable when varicose veins around the ankle are treated, as there is usually considerable swelling following occlusion of varicosities at this site.

INJECTION OF SMALL VARICOSITIES

When the varices are of smaller caliber and covered by a thicker layer of subcutaneous fat, injection with the patient lying down may not be safe. The following maneuvers will be found helpful to render such veins as nearly empty as possible. One or more adhesive strips 1½ to 2 inches wide are applied distally to the site of the proposed injection. These strips, serving as permanent tourniquets, block retrograde flow and permit the vein to collapse considerably. If the varicosity still remains markedly distended, I prefer to make the injection with the patient in a sitting posture, the leg hanging over the table margin. The needle is introduced into the vessel lumen and anchored securely. The leg is raised to a level sufficient to empty the vein and then supported on a chair or on the operator's knee; thus the injection is made into an empty vein. If the adhesive tourniquets produce minimum vein engorgement, injection of smaller varices can be made with the patient in a standing position. Gentle pressure with the needle on the posterior vein wall during the injection will also help to collapse the vein further. An attempt may be made to stretch tortuous or coiled-up veins and to maintain them in this state with adequate compression. The adhesive strips are left in place until the next visit to the office or they may be removed by the patient two or three days later.

To obtain optimum cosmetic results, dilated venules called spider web or hair veins, when associated with varicose veins, frequently may be safely injected with the patient lying down or in the sitting position. The key vein, associated with and feeding these ectasias, is intracutaneous and therefore in a rather fixed position and usually remains sufficiently engorged to permit safe introduction of a fine needle (27 gauge, ½ inch long). If the needle point is outside the vessel lumen, a wheal will appear before less than one drop of solution has been injected. If the needle is in the lumen, a characteristic blanching of the zone will appear due to sclerosing solution replacing the blood leaving the vein. Only slight pressure should be used for the injection of such venules in order to obtain minimum distention, since these small vessels rupture readily. Discoloration caused by the deposit of blood pigments, hematin and hemosiderin, in the perivenous tissues is frequently observed following injection of small veins. This is due to the great permeability of the thin, injured vein walls to sclerosing solution and blood pigments. Therefore, the employment of small amounts of weaker obliterative agents such as invertose 60 to 70 per cent or sodium psylliate, 1 or 2 per cent (sylnasol 5 per cent diluted with sterile distilled water) will lessen discoloration by producing a milder reaction in the vein walls, thereby reducing hemorrhagic extravasation in the perivenous tissues. The employment of weaker irritants for small superficial varicosities gives added insurance against the possibility of necrosis and sloughing following accidental extravascular infiltration. Here, too, firm compression applied immediately after injection is necessary to effect better cosmetic results.

NEED FOR THE EMPTY VEIN TECHNIC

While the empty vein technic may in general be considered the technic of choice for the effective and most pleasant eradication of varicose veins, it must be considered the technic of necessity in the following situations:

1. When injecting superficial, partially intracutaneous veins, and thin-walled, sacculated ectasias (vesicle veins). (Fig. 2.) These are of a more or less deep blue color, covered only by a thin layer of skin. When the patient is in the recumbent position, such vessels rarely collapse to such a degree as to make their injection unsafe. Full vein injection of such varicosities often results in thrombosis with the formation of painful, hematoma-like indurations protruding in the form of knots and strings. Such indurations are very slowly if at all absorbed. When this has occurred, removal of blood clots from such painful

thrombosed veins is often indicated to avoid suppuration resulting in irregular sloughing and scarring.

taneous fat, and full vein injections would, therefore, result in painful indurations which are usually very slowly absorbed.

FIG. 2 A and C, subcutaneous sacculated ectasias (vesicle veins) rupturing spontaneously. A, blocking of the backflow in the incompetent great saphenous vein does not result in collapse of these superficial varicosities B and D, after treatment. These superficial varices can be injected safely only when they are in a collapsed state.

2. In varicosities over bony prominences, as over the anterior surface of the tibia, the patella and about the ankle bones. In these areas there is only a thin layer of subcu-

3. When injecting varicosities in or near areas of chronic thrombophlebitis, dermatitis hemostatica, varicose eczema, psoriasis, etc. These complications, caused or ag-

gravated by the stagnating venous circulation, are frequently exacerbated by gross thrombosis and the resulting perivenous edema. In the presence of chronic thrombophlebitic induration the employment of iontophoresis with mecholyl, as described by Kovacs,[8] will be found helpful to soften such hardened areas before sclerosing therapy is instituted. It is advisable first to inject varicosities situated at a distance from these hard, nonpitting, brawny indurations. After softening with mecholyl iontophoresis, one will frequently find several medium or small-sized varices within the thrombophlebitic area. This group must be injected with the greatest care, the best approach being from without the margin of the thrombophlebitic area. The latter usually remains somewhat pigmented, though considerably lighter in color, even after treatment.

4. Impairment of arterial circulation is considered by some workers a contraindication to active treatment, while numerous others believe that the defective arterial supply will be greatly improved by the elimination of associated incompetent veins.

In the presence of an incompetent internal saphenous system, venous ligation is the method of choice. Excessive thrombosis is to be avoided as the deficient arterial circulation may be inadequate to cope with an extensive local reaction and perivenous edema. When the elimination of such varicosities by injection is desirable, minimun doses of sclerosing solution into empty veins are indicated for safety.

As for choice of sclerosing solutions, I have at present no new experiences to add to the data already presented in a recent publication.[9] I have continued the use of sodium morrhuate 5 per cent without encountering any untoward reactions.

TECHNICAL PROCEDURES EMPLOYED WITH LIGATION AND THE RETROGRADE INJECTION

The advantage of combining ligation with a simultaneous retrograde injection of the great saphenous vein lies in the fact that it will greatly reduce the number of injections required in the follow-up treatment. In many patients the upper segment of the saphenous vein is also most difficult to inject from the surface of the thigh. In the presence of infected ulcers complicating varicose veins, active treatment should be delayed until the infection is under control. Azochloramide in triacetin 1:500 will be found very effective for the treatment of moist superficial ulcerations. The astringent action of this solution will also shorten the healing time. The duration of action can be prolonged by covering the medicated dressing with an impermeable material such as waxed paper or oil silk to prevent absorption by the overlying dressing. The employment of gentian violet 2 per cent in aqueous solution, followed by a bismuth powder, and the use of a nonadherent dressing material are also efficacious in the treatment of superficial ulceration. Adequate support of the superficial venous circulation is of primary importance to accelerate control of infection and epithelialization.

The following procedures will be found helpful to make ligation an uneventful minor operation with minimum postoperative pain and discomfort and will insure better cosmetic results. Before ligating, several small injections into isolated varicosities should be given to ascertain whether or not the patient is sensitive to the solution to be used for the retrograde injection, and to determine, by observation of the degree of reaction and sclerosis following these injections, the optimum amount of solution for the distal injection. If the reactions are severe, the presence of latent phlebitis is to be suspected. Should this occur, it is best to delay ligation and to continue injection treatment with small repeated doses of weaker sclerosing solutions, gradually increasing the amount. This will produce successive, acute phlebitic reactions of a localized and mild nature. The effect of these graduated phlebitic reactions is similar to the action of increasing doses of autogenous vaccines. By the use of these measures, one will

prevent severe secondary thrombophlebitic reactions in the distal segment of the severed vein and surrounding varicosities. Such a reaction occurs from six to eight days after the operation and is usually accompanied by severe local and systemic discomfort.

SUPPORT OF THE THROMBOSED VEINS

Adequate support will greatly reduce postoperative pain and discomfort and will keep most patients ambulant. This support is best applied immediately before the operation and should be continued until subsidence of the swelling and pain. An elastic bandage, such as the Ace bandage, Ace lastex bandage or a similar bandage, applied firmly from toes to knee while the patient is in a recumbent position, will secure effective compression of the varicosities of the leg. In the presence of varicose eczema or dermatitis hemostatica, a zinc gelatin bandage such as cruricast is preferable. An elastic adhesive bandage, such as the Ace lastex bandage will also secure firm support, especially in the presence of edema, but it should be applied only on healthy skin. Areas of skin lesions, such as secondary weeping eczema or dermatitis, should be covered with a cod liver oil ointment or a mild tar product and gauze before the application of an adhesive bandage. A nonadherent covering such as oil silk or strips of waxed paper over the medication will help protect new granulations and epithelialization.

Adequate support of the great saphenous vein and the surrounding varicosities of the thigh is best attained by the application of a nonslipping support such as adhesive strips or an elastic adhesive bandage. This support should be applied with even pressure avoiding strong tension. It is advisable to unroll the elastic bandage for about ten inches before applying, to avoid compression of the thigh by the force used to unroll the bandage. Dr. Tunick[10] makes the retrograde injection after the extremity has been slightly elevated. To prevent leakage from the puncture hole, a needle of small gauge is preferable for this injection.

An endeavor was made to keep the "before and after treatment" illustrations similar both in size and tone gradation, as only then are they useful for clinical evaluation.

CONCLUSIONS

1. Treatment of varicose veins can be effected with a minimum of pain, discomfort and disability. In a high percentage of cases, ligation is essential for effective treatment. The empty vein technic, though more difficult from a technical point of view, will greatly contribute to good end results.

2. Adequate compressive support (compressive collapse) is of primary importance to achieve painless sclerosis and good cosmetic results.

3. Methods of technic must be varied and individualized to suit the different veins in individual patients.

4. Overtreatment is to be avoided since it usually leads to insufficient treatment, as the patient, discouraged by distressing sequelae, gives up treatment at an early stage.

5. It is desirable and possible to obtain good cosmetic results, not a negligible factor in the treatment of varicose veins.

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CONGENITAL DISCOID MENISCUS*

A CAUSE OF INTERNAL DERANGEMENT OF THE KNEE

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CONGENITAL anomalies of the semilunar cartilages should always be kept in mind when attempting to make a differential diagnosis in a case of internal derangement of the knee. It is particularly true in children and adolescents. To date, a congenital anomaly of the meniscus has not been a very common finding. In 1889, it was first seen in an anatomical specimen and described by Young of Glasgow. It was not until 1910, however, that this anomaly was associated with symptoms of internal derangement of the knee. At this time Kroiss reported a disc-shaped external meniscus with a horizontal split (as in one of our cases: R. G. No. 5702, Fig. 3) which he had removed surgically. Since that time, cases of discoid semilunar cartilage with clinical symptoms have been reported in increasing numbers, beginning with Bristow's report in 1927. To date over fifty cases have appeared in the literature. All anomalies reported, as far as we could determine, were those of the external meniscus with one exception (R. Watson-Jones). The report of a completely disc-shaped internal meniscus has not been found in the literature.

Occurrence. Naughton Dunn reported eight cases of discoid type external cartilage occurring in a consecutive series of two hundred ninety-five cases of internal derangement of the knee; this proportion agrees with our findings. In a ten-year period at the Massachusetts General Hospital there were one hundred sixty-four patients operated upon for internal derangement of the knee. In this series there were four cases of congenital anomaly of the meniscus, an incidence of 2.4 per cent.

To these four we have added in this report three cases in which the patients were operated upon by us.

Development. The embryological background of the disc-shaped meniscus has been previously discussed by Jaroschy, Fisher, and others. The lizard is the highest form in which the completely disc-shaped meniscus normally appears. Jaroschy believes that comparative anatomy studies throw little light on the occurrence of this anomaly in man.

Symptoms and Signs. Symptoms may begin at any age but are most apt to occur in children or young adults. The ages, in years, of our seven cases were: 8, 10, 10, 13, 19, 19 and 19, respectively, the average being fourteen years. The disability may follow a definite injury to the knee, severe or slight, or may begin without trauma. In five patients symptoms began with a definite injury and in only two was there no trauma. The outstanding complaint as a rule is a snapping sensation accompanied by an audible click, or thud or jar when the knee is flexed or extended. As a rule active motions more effectively produce this sound. This is sometimes associated with pain. Usually there is little reaction in the knee except after an acute episode causing an increase in joint fluid. Motions are frequently unrestricted. A palpable tender mass may be felt along the joint line and its prominence is exaggerated as the knee is brought from a flexed position to extension.

X-ray Findings. Roentgenograms are usually negative except perhaps for widening of the joint space between the external (or internal) condyles of the femur and tibia.

Pathology. Of the cases reported in the literature almost half exhibited a split or tear or other form of injury constituting the mechanism by which pain or locking occurred. In the remaining cases, which showed no injury, the cause of snapping or locking was usually obscure. Middleton observed at operation a transverse ridge in the central portion of the meniscus which caused the jog of the knee as the femoral condyle rode over it in flexion and extension. This mechanism he demonstrated in two of his four patients operated upon.

In our cases we did not encounter the situation which Middleton described. Only two of the seven cartilages were free from injury. The snapping and pain in one of these was due to a transverse ridge in the external femoral condyle on the weight-bearing surface, which appeared to engage the thickened mobile meniscus during flexion and extension, and thus caused a jog and thud as the knee was moved beyond that point. (Case II, M. B.) In the other case, the snapping sensation and the audible click on motion of the knee were due to a combination of relaxed crucial ligaments and the thickened and broad meniscus.

In this series there are five anomalies of the external meniscus and two of the internal. Three external cartilages were complete discs; the remaining four were discoid in type but showed some evidence of semilunar shape.

Treatment. Internal derangement of the knee joint due to a congenital anomaly of the semilunar cartilage should be treated by excision of the cartilage whether it is damaged or not. In our series, five of the seven cases showed evidence of injury to the cartilage but all were relieved by excision. Usually removal of such structure presents no difficulty and can be accomplished with either the Fisher, Jones, or combined anteroposterior incisions.

CASE REPORTS

CASE I. E. T. No. BM15105, age nineteen, a male, nine months before while playing football, was struck by a tackler on the outer side of the right knee. Swelling and pain followed, lasting two days. Brief locking of the knee had occurred several times since then. Since the injury he could produce snapping in his knee by flexing it with the leg held in external rotation.

Examination revealed slight atrophy of the thigh. No tenderness or masses were felt. There was no joint effusion and full range of motion was present. There was no increased lateral mobility but definite increased anteroposterior mobility, in 90 degrees flexion. Snapping of the knee could be produced by passive flexion with the leg held in external rotation. X-rays revealed an old fracture of the tibial spine.

The Fisher incision was used at operation. On opening the joint, the external semilunar cartilage was found to be thickened and formed a complete disc covering the external condyle of the tibia. The cartilage showed no evidence of injury. The crucial ligaments were relaxed but intact. The discoid cartilage was completely removed. The relaxation of the crucial ligaments and the discoid meniscus accounted for the patient's symptoms.

One year later the patient was symptom free with normal knee motions and full activity.

CASE II. M. B. No. U78882, age ten, a female, six weeks before, without history of injury, began to have locking of the left knee which was easily reduced, but accompanied by pain on the outer side of knee. During this time there had been snapping on flexion and extension. There had never been swelling of the knee.

There was one-half inch atrophy of the thigh. Tenderness was present over the external joint line posteriorly. Examination revealed no joint effusion and full range of motion. No increased anteroposterior or lateral mobility were present. On flexing and extending the knee there was an audible thud accompanied by a jog of the tibia on the femur which could be seen and felt. This occurred at 30 degrees and again at 120 degrees flexion. X-rays were negative.

Operation was performed with a Jones incision. On opening the joint, a thick completely discoid external meniscus was seen. The cartilage was removed *in toto*. There was no split or evidence of injury. There was a prominent ridge on the external femoral condyle which impinged against the anomalous thickened cartilage and caused the snapping of the knee. One year postoperatively the knee was

normal and no symptoms were evident. X-rays were negative.

CASE III.   R. G. No. U57402, age nineteen,
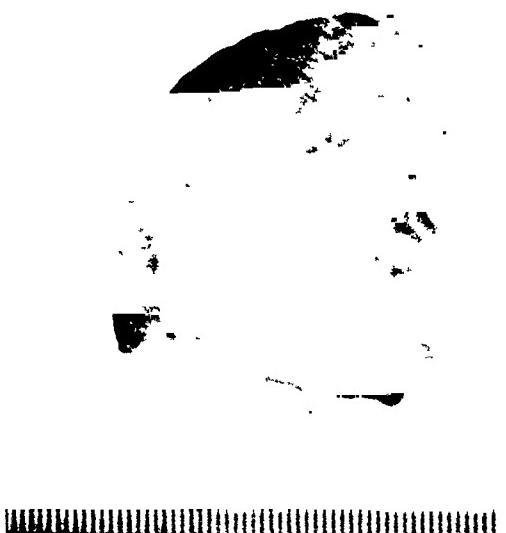
FIG. 1. Case 1. Complete discoid external semilunar cartilage; no damage to the meniscus.

a male gave no history of injury. Locking of left knee had occurred as long as he could remember. It always occurred in full flexion, could be released by pressing a protruding mass in the external tibiofemoral fossa and was accompanied by little or no pain. On a few occasions there was swelling and pain on the outer side of joint lasting a few days following minor strains.

Examination revealed a slight atrophy of the thigh; tenderness was present over the entire external joint line to a slight degree. A small firm mass appeared in the external tibiofemoral fossa on full flexion of the knee; this could be pushed back into the joint without pain. There was no joint effusion; full range of motion was present. X-rays were negative.

At operation the Fisher incision was used. The external cartilage was thickened and disc-shaped covering the entire external condyle of the tibia. The cartilage was removed in toto. There was a horizontal split in the cartilage involving the posterior two-thirds, dividing this portion of it into a superior and inferior layer. Full flexion of the knee would cause the superficial layer to roll forward (Fig. 3) and give rise to the locking and make the mass palpable.

Two years later the patient was symptom free. The knee was normal except for slight

relaxation of the joint and slight quadriceps atrophy.

CASE IV.   A. A. No. U188663, age fourteen,
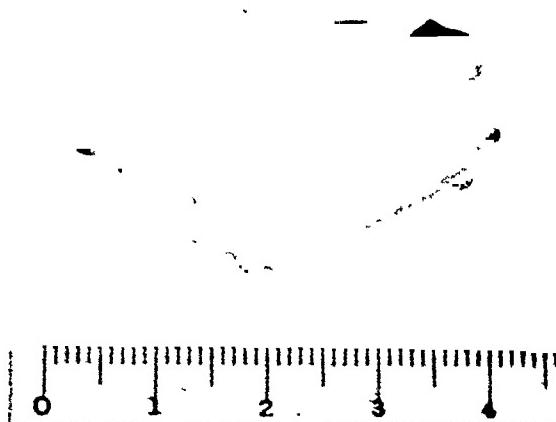
FIG. 2. Case II. Complete discoid external semilunar cartilage; no evidence of injury.

a male five months before entry while playing football fell striking his left knee on a cement walk. Pain followed immediately and persisted up to the time of admission. Since the injury his knee during active extension had frequently snapped and caught, but true locking had never occurred.

Examination revealed three-fourths inch atrophy of the thigh; tenderness over the external joint line anteriorly; slight joint effusion; permanent flexion of 5 degrees, otherwise normal joint motion. On extending the knee from a flexed position a tender mass became palpable in the external tibiofemoral fossa. There was no jog or audible thud accompanying it, and no increased anteroposterior or lateral mobility. X-rays were negative.

At operation the Fisher incision was employed. The external semilunar cartilage was thickened and of the discoid type, covering almost the entire surface of the external condyle of the tibia. It was removed in toto. Anteriorly, the inner margin of the cartilage was crescentic, and medial to it a portion of the external condyle of the tibia was exposed. Posteriorly, the cartilage was completely discoid and was split transversely. (Fig. 4.)

Ten months postoperatively the knee was symptom free. There was no quadriceps atrophy; the joint motions were normal and there was no instability.

CASE V.   J. L., No. U111104, age thirteen, a male, fell twisting his right knee two months

before entry. Pain persisted for one day. Five weeks before entry, when suddenly arising from kneeling position, he had pain in his knee,

At operation vertical anterior and posterior incisions were used. The internal semilunar cartilage was seen to be "twice or three times "
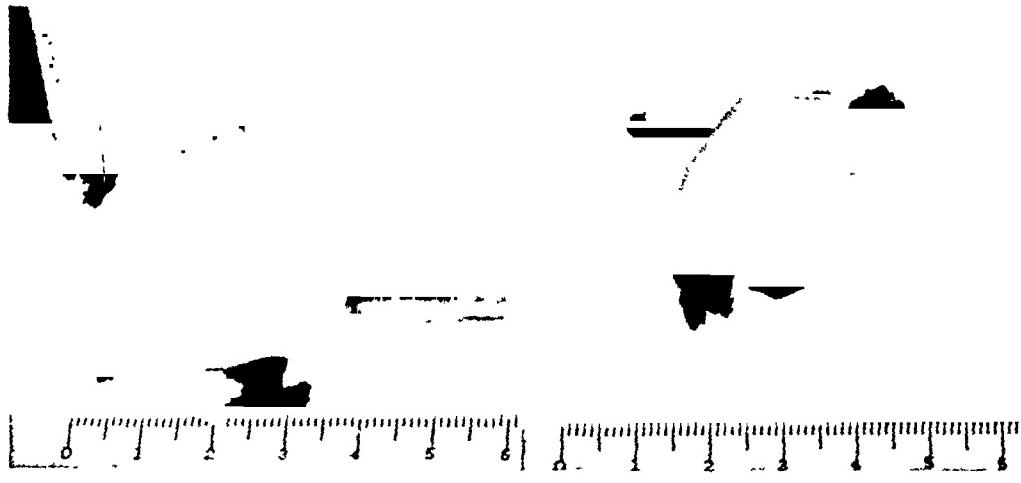
FIG. 3. Case III. A, complete discoid external semilunar cartilage with horizontal split posteriorly. The superior portion is turned up and forward. B, shows split superior portion returned to its normal position.

accompanied by flexion deformity and swelling. These symptoms persisted until entry.

Examination revealed three-quarters inch atrophy of the right thigh; tenderness over the internal joint line anteriorly; no mass was felt. There was a slight amount of increased fluid in

as thick and as wide as normal, and contained a "bucket-handle" split. ("It was apparent that the cartilage was of the congenital discoid type.") The split portion, attached at both ends, had been dislocated into the intercondylar notch. The entire cartilage was removed.
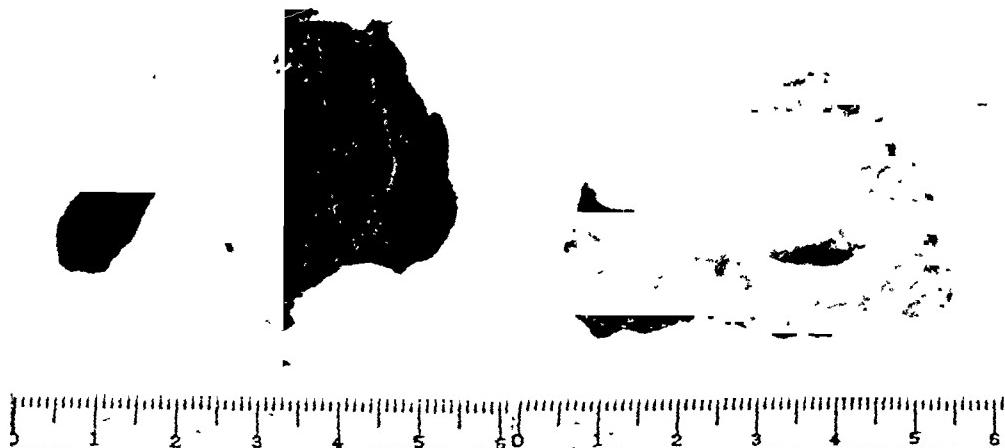
FIG. 4. Case IV. Discoid type external semilunar cartilage with transverse split in posterior portion.

FIG. 5. Case V. Anomalous internal semilunar cartilage with a "bucket-handle" split; incompletely discoid in type with concave inner border.

the knee joint. Permanent flexion of 15 degrees with further flexion of 135 degrees. There was no increased anteroposterior or lateral mobility as compared with the opposite knee. No audible or palpable snapping was present. X-rays were negative.

Two years later the knee was symptom free; motions were normal, and there was no quadriceps atrophy or instability.

CASE VI. H. R., No. 342881, age eight, a male, four months before entry, injured his

right knee while playing football. There was pain for a few hours after injury but no locking. On the following day there was a second injury

thigh. Tenderness was present over the entire external joint line; no mass was felt; slight joint effusion was present and full range of

Fig. 6. Case vi. Partially discoid internal semilunar cartilage with a split at its anterior portion.

Fig. 7. Case vii. Incompletely discoid type external semilunar cartilage; transverse split present in its midportion.

while playing football, followed by pain and flexion deformity. He was treated by rest and casts, with only partial improvement.

Examination revealed no atrophy of the thigh. A firm mass was felt in the internal tibiofemoral fossa. On flexion this mass disappeared within the joint. There was no tenderness and no joint effusion; there was 10 degrees permanent flexion and complete flexion. No increased anteroposterior or lateral mobility was present as compared with the opposite knee. X-rays were negative except for widening of the mesial joint space.

A Fisher incision was employed, exposing the internal semilunar cartilage; the cartilage was found to be torn at its anterior insertion. The cartilage was discoid in type covering the major part of the internal tibial condyle. It was entirely removed.

Two years later normal motion and full activity were present. No pain, no knee symptoms and no instability were present.

Case vii. M. C., No. PH37320, age nineteen, a male, while playing squash rackets, slipped and twisted his knee five months before entry. His knee locked. During the course of a month pain in the knee diminished, and motion gradually improved. Since then he has had a "popping" sensation on the outer side of the knee whenever he extended it.

Examination revealed no atrophy of the

motion. In flexing and extending the knee a "thud" could be felt on the external side of the joint. X-rays were negative.

Operation was performed using the Fisher incision. The external cartilage was abnormally thick and wide. The anterior four-fifths of the cartilage was removed. A transverse split was present in the midportion. The cartilage was of the discoid type although the external tibial condyle was not completely covered by it. The posterior portion especially was enlarged, being two to three times as wide as the ordinary cartilage.

Two months later the patient was symptom free. There was no increased joint fluid, no permanent flexion and no instability.

SUMMARY

Congenital discoid meniscus is not an uncommon cause of internal derangement of the knee. It occurs much more frequently in the external than in the internal compartment of the joint. It usually causes symptoms in childhood or adolescence, and an injury may or may not precipitate the difficulty. The symptoms and signs are those of internal derangement, and the treatment should be operative removal of the anomalous cartilage. The discoid member may or may not show signs of damage. The operative results are uniformly good.

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Ankylosis of a joint or stiffness of the adjacent soft parts is due not to immobilization but to pathologic changes. Such changes in turn are due to irritation, inflammation, tissue destruction, and scar formation.
From—"Wounds and Fractures" by Orr (Charles C. Thomas).

CHRONIC SCLEROSING OSTEOMYELITIS: GARRÉ

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CHRONIC osteomyelitis is a disease which is being more frequently observed. There is considerable literature discussing the acute and chronic forms of osteomyelitis. However, the few papers which have appeared discussing the type described by Garré are evidence of its rarity. This unusual disease still presents a problem in diagnosis and treatment.

In 1893, Garré[3] discussed the disease which bears his name. The picture was that of dense sclerosis of bone without suppuration. Trendel[9] in 1,299 cases of osteomyelitis reported fifty-four, and Henderson[5] in a group of 1,968 described thirty cases. In another report of 559 cases, from the Tubingen clinic, twenty showed neither suppuration nor necrosis. There are infrequent references in the literature, and a few textbooks on surgery briefly mention the disease. Jones,[6] in 1921, reviewed the literature and presented a case of his own. Other writers particularly Bloodgood[2] and Geschickter and Copeland[4] have discussed the subject and the problems it presents.

ETIOLOGY

The disease has the characteristics of an infectious lesion although in some cases the infectious agent cannot be demonstrated. There is a low grade persistent irritation which results in fibro-osseous proliferation without suppuration. Wishner[10] reported a growth of Staphylococcus aureus in three out of five cases. Bennett and Hopkins[1] have reported a case in which Trichina were found in the muscle adjacent to the diseased bone. Whether the presence of this parasite in the soft tissues was sufficient to cause persistent irritation of the bone and sclerosis is problematical. Garré reported three out of four cases in which the Staphylococcus aureus or albus were isolated. Swett[8] reported two cases after fracture of the tibia, not compounded, in which the persistence of pain made a later operation necessary. Eburnated bone was found in each case at the site of the healed fracture. Removal of a section of cortex resulted in definite improvement. The microscopic sections showed, "focal necrosis of bone." No culture was reported. Staphylococcus aureus hemolyticus was cultured from the curettings of the bone in the case herein reported.

PATHOLOGY

The tibia is said to be the bone most often involved, and that it occurs in males more often than females. The femur was involved in the case observed by the writer. There is a low grade infection of the lymphatics of the bone. By Kaufmann[7] it is called "osteitis ossificans, condensing osteitis, or osteosclerosis." The lesion is usually solitary. It consists of a formation of new bone arising from the marrow cavity and vascular channels and encroaching upon the old trabeculae. The marrow cavity gradually becomes narrowed or obliterated, the cortex widened and its density increased to ivory-like consistency. With this osseous proliferation there is an increased fibrosis. (Fig. 5.)

SYMPTOMS

The following case illustrates the history, the signs and symptoms of the disease and a complication not presented heretofore in the cases reported:

CASE REPORT. M. O., a female, age twenty-eight years, a secretary, had recurring pain in the elbows, wrists, fingers, right knee and ankle, for seven years. The patient began having pains seven years before in most joints, not constant

but with frequent recurrence. The pain was aggravated by activity and abated some with rest. Her physicians had at various times

has chronic arthritis; one sister died of rheumatic heart disease; one aunt had arthritis, and her father died in 1940 of heart disease.

FIG. 1. Right femur (September, 1937): There is thickening of the cortex and medulla in the lower third. Periosteal irregularity with linear shadows of increased density in the soft tissues are present posteriorly. There is a multiple cystic appearance in the lower part which culminates in a large cystic area in the lateral condyle. With the exception of a small amount of squaring of the bony margin of the joint nothing else unusual is noted. Findings suggest osteomyelitis of Garré.

examined her and made the diagnosis of rheumatoid arthritis and appropriate treatment rendered. X-ray of teeth was negative for infection. Streptococcic agglutination was negative, sedimentation rate was 0.42.

In 1935, symptoms of low-grade recurrent appendicitis appeared. Operation was performed and an atrophic appendix removed with release of congenital adhesions of the cecum and lower ascending colon. In 1936, following an episode resembling "grippe," joint pains recurred with elevation of temperature to 100°F.

Her past history was negative for either chronic or acute infection, except for the above mild attack of "grippe." There was no history of trauma to the extremities. Tonsils had been removed at the age of seven years. Her mother

Examination was negative except as follows: swelling and tenderness about the right knee and ankle; no redness, increased heat or induration; there was tenderness to pressure over the condyles of the femur. The following was the result of the laboratory tests: white blood cells 6000–10,280; polymorphonuclears 60 per cent; lymphocyte 30 per cent; hemoglobin 82 per cent; red blood cells 4,250,000; sedimentation rate 0.3; streptococcic agglutination 1:1280 only. Serum studies: calcium 11.1; phosphorus 3.7; Wassermann blood test negative.

X-rays. All long bones and joints were x-rayed with the positive findings as follows: "Films of the right femur show thickening of the cortex and medulla in the lower third. There is some periosteal irregularity with linear shadows of increased density in the
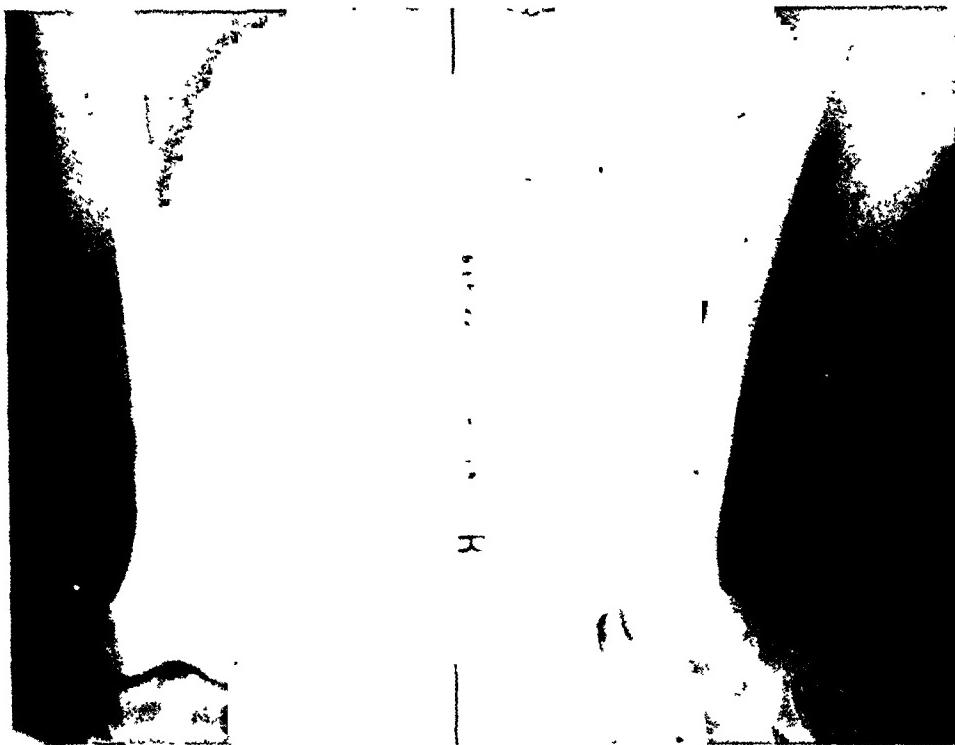
FIG. 2. Right femur (September, 1938): This differs from the normal in that the fine trabecular markings are not made out; there is a diffuse density of moderate degree obscuring the lower fifth of this femur. The lateral cortex is rather rough and somewhat thicker than the left, and there is one drill hole visible. A surgical excavation can be seen extending from this region into the lateral condyle. These changes are characteristic of osteomyelitis, but the changes are only to a mild degree.

FIG. 3. Right femur, after the third operation (October, 1939): There are four drill holes in the lower end. A small defect on the lateral cortex, approximately 7 mm. long, can be traced back to the two previous examinations and is doubtless to be accounted for by the channeling of the cortex of the bone two years ago that produced the thinning of the lateral cortex in this region. The femur certainly shows no progressive process and comparing the films of two years before, the bone in the lateral half of the femur in the lower fourth has a more nearly normal texture now than then.

soft tissues posteriorly. The thickening is fairly uniform in the superior portion but there is a multiple cystic appearance which

After further study of the films the roentgenologist stated, "the diagnosis lies between chronic osteomyelitis and malignant bone
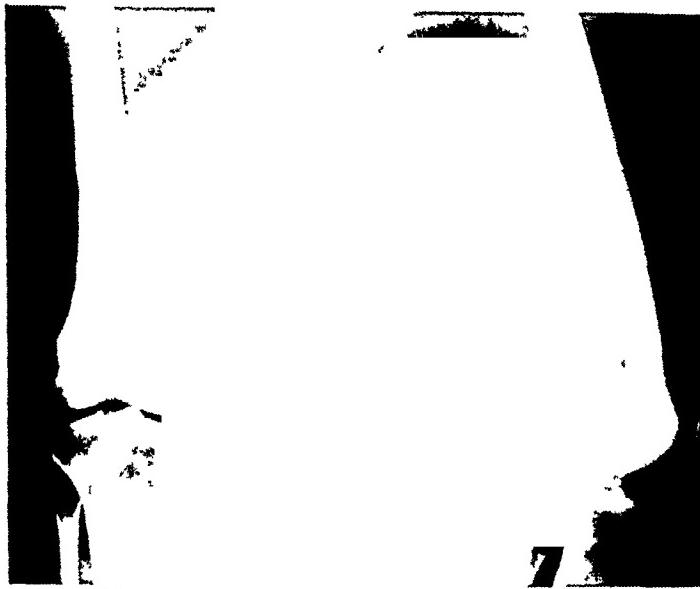
FIG. 4. Right femur (May, 1940): The bone is very nearly normal in appearance. There is nothing to suggest present disease.
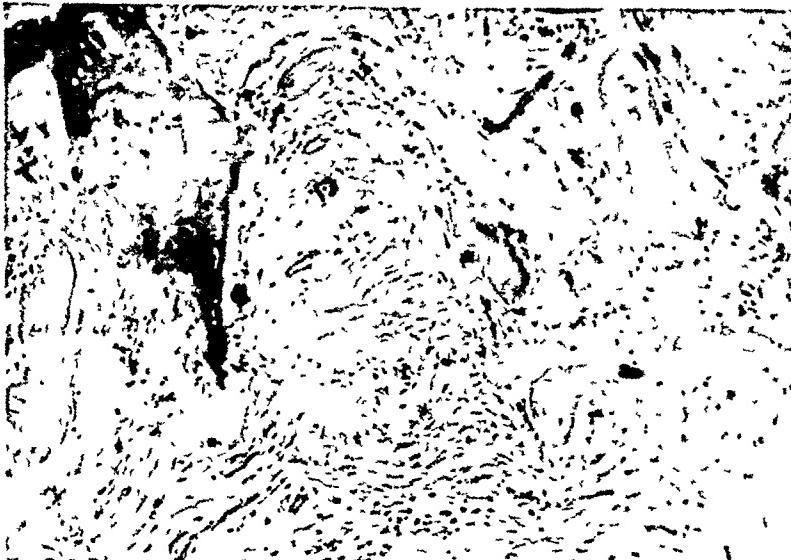
FIG. 5. Photomicrograph showing a complete replacement of the normal marrow by fibrous tissue that is rather sparsely vascularized and shows slight lymphocytic infiltration. The bone trabeculae, in this instance, do not show the widening and encroachment upon the marrow spaces that are seen elsewhere in the section and which is evidenced in the gross examination by extreme eburnation. Diagnosis: chronic osteomyelitis of Garré. × 400.

culminates in a large cystic area in the lateral condyle. With the exception of a small amount of squaring of the bony margin of the joint nothing unusual is noted.

"Impression: Findings suggest osteomyelitis of Garré."

tumor." Because of persistent pain, the patient was advised that operation was indicated and this was carried out in 1937.

An incision was made on the outer aspect of the right lower thigh. The soft tissues appeared normal. The periosteum of the femur was

smooth and glistening and easily separated from the underlying cortex which was irregular and rough. Two drill holes were made and a portion of the cortex removed. This was hard, of ivory-like consistency, considerably widened, with the marrow cavity almost obliterated. There was very little bleeding from the bone and no evidence of suppuration. The tissues were closed in layers.

Four weeks later because of persistent pain, the same region was explored and a section of eburnated cortex, one inch wide and four inches long was removed. The cyst (?), as shown by x-ray, in the external condyle was curetted and contained granulation tissue only. The tissues were closed in layers with a rubber drain placed down to the muscle. A serous type of drainage persisted for five weeks.

The patient was discharged from the hospital four weeks later and for four months no weight bearing was permitted. Then she gradually increased the use of the leg and seven months from the time of operation returned to normal activity.

Five months later pain in the right lower thigh recurred and for the first time tenderness developed on the inner aspect of the lower right thigh. There was redness, induration, and increased heat with the patient's temperature elevated to 100°F. These attacks lasted two to three days but recurred about every two weeks. Repeated x-rays of the femur revealed a gradual improvement in the appearance of the bone. However, these episodes occurred with increasing frequency, persisting longer, and gradually incapacitated the patient. Although the signs were superficial and x-rays showed the femur gradually becoming more normal, it was believed that infection of the bone had gradually involved the soft structures of the lower thigh. Consequently, a third operation was resorted to, two years following the previous one.

Third Operation. A long incision was made along the inner lower right thigh. Within the ligamentous expansion of Vastus medialis there was an area 1½ cm. in diameter consisting of granulation tissue surrounded by thickened but otherwise normal appearing ligament. This tissue was excised. The incision was deepened down to the femur without encountering further evidence of inflammation. The periosteum was not thickened and easily separated from the entire circumference of the underlying cortex

which was smooth. Four drill holes were made. The cortex appeared normal in density and thickness and there was free bleeding from the drill holes. No pus was encountered. The tissues were closed in layers.

Six x-ray treatments were given because of some tenderness persisting medial to the patella about one inch from the previous inflammatory site. The patient was kept inactive for three months.

Fifteen months later the patient had remained relatively well but periodically there was mild pain about the right knee and occasional episodes of tenderness in the tissues in the region of the previous operative site. X-rays of the femur have been negative for further evidence of inflammation.

Pathological Report. Bone from first operation; sclerosing osteomyelitis. (Fig. 5.) Culture of granulation tissue, Staphylococcus aureus hemolyticus of low virulence; ligamentous tissue from the third operation; chronic desmositis. (Figs. 6 and 7.) Culture of tissue from third operation; an unidentified diplococci.

The above case illustrates the symptoms characteristic of this interesting disease: first, its chronicity extending over a period of years; secondly, its similarity, in the early stages to rheumatoid arthritis; thirdly, the recurring exacerbations with elevation of temperature, moderate elevation of leucocytes without significant change in percentage of polymorphonuclears, and increased pain in the area involved. The absence of preceding infection or trauma was noteworthy.

DIAGNOSIS

Sclerosing osteomyelitis is to be differentiated from syphilis of the bone and sarcoma. Osteal night pain is common in syphilis and osteomyelitis and the tibia is said to be most frequently involved in both. However, the various stigmata and a positive Wassermann blood test rule out lues.

The real difficulties lay in differentiating osteomyelitis from sarcoma. The clinical findings in each are similar. An initial rise in temperature occurs in both. The duration of symptoms averages ten months

(Geschickter,[6]) in sarcoma, whereas it is usually years in osteomyelitis. An elevation of leucocytes may be present in both.

this is not constant. Sarcoma (Ewing's) begins mildly but rapidly produces, within a few months, acute symptoms, whereas in

FIG. 6. Above; ligamentous tissue that is rather widely infiltrated by lymphocytes and not too well vascularized. There is no marked degeneration other than a certain amount of hyaline swelling. The striking feature is the large number of lymphocytes scattered through the tissues. Diagnosis: chronic desmositis.

FIG. 7. Below; a loosely organized granulation tissue is shown here in which several foreign body giant cells are well demonstrated. There is one area of extensive hemorrhage. Note that the giant cells are unassociated with epitheloid cells and that there is no caseation. Diagnosis: same as Figure 6.

A loss of weight is common in sarcoma but also may be a finding in osteomyelitis. With the latter disease, there is more commonly infiltration of soft parts, but

sclerosing osteomyelitis there is often an acute onset with fever and leucocytosis which rapidly subsides into a chronic course extending over a period of years.

The x-ray appearance in the typical case differs somewhat although the area of tumefaction in osteomyelitis resembles the early stages of Ewing's sarcoma. There is formation of new bone in the periosteal and cortical zones. As a result the medullary cavity is narrowed or obliterated while the cortex is widened and its density markedly increased. Ossification is more pronounced than in sarcoma. Furthermore, sarcoma shows a dense formation of bone in some areas and secondary destruction in others producing a difference in structure or mottling effect. This also may be confusing as a similar x-ray appearance at times occurs in sclerosing osteomyelitis. This is due to the areas of increased fibrosis within the bone structure which cast a less dense shadow producing the variation in density. It is not always possible to distinguish definitely between the two and the resort to biopsy may be necessary.

TREATMENT

Exposure of the medulla by generous removal of the overlying cortex and consequently the eburnated bone has proved the most satisfactory measure. Bacteriophage, deep x-ray therapy, and vaccine have been tried with apparently some but no lasting benefit. The case above responded well to removal of a generous part of the ivory-like cortex and the subsequent long period of rest. This is an important adjunct in the treatment of this unusual disease.

The recurrence of symptoms was at first thought to be the result of a sinus extending upward from the bone. They were due, however, to the subacute ligamentous inflammation which required the third operation for its relief. The deep x-ray therapy was no doubt an important factor in relieving the second site of ligamentous inflammation at the inner border of the patella which appeared shortly after this operation.

The patient still has some discomfort in the right lower thigh after undue activity. There is no limitation of motion at the knee joint, but there is some discomfort during the extremes of motion. The length of the right leg is the same as the left. Circumference of the thigh at the upper margin of the patella and that of the calf is 1 cm. less than that of the left at the same levels.

SUMMARY

1. A case of chronic sclerosing osteomyelitis is presented.

2. Its pathology is the result of a persistent irritation of the bone by an infectious agent most commonly a Staphylococcus aureus of low virulence.

3. Its diagnosis is not always easy and is to be differentiated from syphilis of the bone and Ewing's sarcoma.

4. Treatment is not entirely satisfactory but it responds best to surgical intervention.

5. Subacute desmositis is a rare complication and one heretofore not described as a complication of this disease.

6. A long period of inactivity and deep x-ray therapy is an important adjunct in treatment.

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GENERAL CONSIDERATIONS OF FISTULA-IN-ANO*

THE RÔLE OF FOREIGN BODIES AS CAUSATIVE FACTORS

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FISTULA-IN-ANO has been one of the earliest known afflictions of mankind as evidenced by mention of its existence in early Biblical literature.[1] However, the first surgical treatise on anal fistula is accredited to John Arderne, an English surgeon of the fourteenth century.[2]

Much has been written about anal fistula since Arderne's time, but the surgical principles remain the same, namely, finding the internal opening and then completely excising the tract.

Simple fistula-in-ano is found more commonly in males than in females. No satisfactory explanation for this has been advanced. The distribution among the sexes shows about 70 per cent occurring in males.[3,4] Buie[5] found the incidence in males to be about 60 per cent.

Anal fistula comprises less than 1 per cent of the total number of admissions in general hospitals. This is shown in Table 1.

TABLE I
INCIDENCE OF SIMPLE FISTULA-IN-ANO IN GENERAL HOSPITALS

Observers	Hospitals	Year	No Admissions	Fistula or Abscess Number	Fistula or Abscess Per Cent
Leslie[6]	Vancouver Gen	1924	4648	24	0.52
Leslie[6]	Mass General	1924	4351	30	0.69
Author	Brooklyn Hosp.	1930–39	7372	532	0.69

Anal fistula and perianal abscess are always intimately associated, the abscess being a concomitant or precursor of the fistula.

Injury to the anal crypts with subsequent infection is considered to be the main factor in the production of fistula. These crypts, situated at the pectinate line, dividing the rectum proper from the anal canal, open as pockets facing the rectum above. They are constantly exposed to repeated trauma and infection from the fecal stream above, and often serve as receptacles for foreign bodies coming down from the upper intestinal tract.

In regard to tuberculosis as a cause of fistula-in-ano, it is now believed that the tubercle bacillus is only a secondary invader of the anorectum, the primary source of infection being usually in the lung.

Not so long ago, anal fistula was considered to be always of tuberculous origin. Richard C. Cabot,[7] in his book on "Differential Diagnosis," stated that fistula in ano was a tuberculous affection in practically every case. This belief has been disproved by clinical and scientific investigation. "In no instance," says Buie,[8] "has evidence of tuberculosis been found within tissue removed from a fistulous tract unless patients harbored either active or quiescent foci of tuberculosis in other parts of the body."

It is the opinion of diligent observers that in general hospitals the incidence of tuberculosis in anal fistula is about 2 per cent. In Buie's[5] series of 1,000 cases of fistula 2.2 per cent were considered to be of tuberculous origin on histopathologic examination. Bacon,[9] in a series of 400 cases found the incidence of tuberculosis in anal fistula to be 1.7 per cent.

In active cases of pulmonary tuberculosis, the incidence of tuberculous anal fistula is much higher. Table II shows the

incidence of fistula as a complication of pulmonary tuberculosis.

Observer	Year of Report	No. of Cases	Hospital	Per Cent
Clarke[10]	1924	185	City of London, Hospital of Heart and Lungs	6.0
Petter and Fansler[11]	1931	1500	Glen Lake Sanatorium	6.0
C. L. Martin[12]	1933	10000	Chicago Municipal	7.0
Marino, Buda and Skir[4]	1938	357	Kingston Avenue	11.7

In a discussion of anal fistula, mention must be made of the anal ducts and anal glands. The existence of these structures has been a subject of controversy among anatomists, although Tucker and Hellwig[13] seem to have demonstrated convincingly their existence and histologic appearance. They are considered vestigial organs and are found also in some of the lower animals.

These tubular branching structures pass into the muscular coat of the anal canal and are lost in the connective tissue. Some are said to pass through the internal sphincter fibers and to terminate in the ischiorectal fossa.

Tucker and Hellwig conclude that cryptitis, anal fistula and perirectal abscess originate in these preformed anal ducts, and that these ducts explain the frequency of anal infections.

Pope and Gunn[14] have done similar work along these lines and have been able to confirm all the findings of Tucker and Hellwig. They were also able to demonstrate a definite inflammatory reaction of the crypt wall itself.

As Hayden[15] remarks, "These researches, coupled with the fact that the internal opening of an anal fistula, in the majority of cases, is found in the depths of a crypt, would seem to provide convincing evidence that most if not all perirectal abscesses from which fistulae develop, are a direct result of inflammation in the crypts and their subsidiary ducts."

And, as Buie[8] states, "There never has been an anal fistula without a primary internal opening, and that opening is always in the anal crypts. All abscesses of anal origin come from a source within the anal crypts."

Man has always dreaded fistula and has feared the operation for its cure. This is not without good reason; for, in some instances, not only is the patient not cured of his disease, but a greater affliction confronts him in the form of anal incontinence due to poor surgical management. As Lockhart-Mummery[16] has said, "A fistula operation is not a major operation, but it is far from being a minor one."

Successful operation for anal fistula involves certain well established principles. One of the first objectives to be obtained in its cure is to provide adequate drainage, and this drainage must continue throughout the process of healing. All subsidiary tracts must be sought and exposed and freely excised. The fistulous tracts should be excised in such a way as to convert the areas into wedge-shaped fossae, the skin wound being larger and wider than the deeper wound. This allows the base of the wound to heal sooner than the surface wound, thus affording continuous drainage of the deeper structures until complete healing results.

At times it becomes necessary to incise the sphincter muscle when a fistulous tract lies beneath it. It is advisable in such cases to cut the muscle transversely and in one place only, as otherwise incontinence may supervene.

When one is dealing with an extensive fistula, the operation may have to be done in several stages so as to avoid serious damage to the anal musculature. When two separate internal openings exist and the tracts lie beneath the sphincter muscles, the operation for each fistula should be done at different times. The second operation should be performed only after complete healing takes place following the first operation.

It is not advisable to pack the resulting wounds tightly or for more than twenty-four hours where the sphincter muscle has been incised; for this tends to keep the severed muscle ends apart, preventing their union and thus predisposing to anal incontinence. Bridging of tissue during healing should be prevented.

In tuberculous anal fistulae, in cases in which the patient's sputum is negative, the wounds heal about as quickly as in non-tuberculous subjects. In patients with positive sputa, the prognosis as to complete healing is usually good, although convalescence is often protracted.[4]

Surgical judgment at the time of operation, finding of the primary opening, judicious and adequate postoperative care are all important factors in the successful outcome of fistula operations.

Low spinal anesthesia is well suited for operations for anal fistula as this gives complete relaxation to the parts involved with least inconvenience to the patient.

We have found the prone, inverted V (Depage) position superior to the lithotomy position in operations about the anorectum.

FOREIGN BODIES

Instances of foreign bodies in anal fistulae occur perhaps oftener than recorded, either because the surgeon fails to look for them at the time of operation, or, as often happens, the foreign body is extruded at the time the abscess ruptures spontaneously, or at some other time before operation.

In the ten year period from 1930 to 1939 there were 532 patients operated upon at the Brooklyn Hospital for fistula-in-ano or abscess with fistula. In only five cases (0.9 per cent) was a demonstrable foreign body recorded as having been found at operation. As stated above, it is the author's opinion that this is only a small percentage of cases in which a foreign body was actually responsible for the fistula. No doubt, in many of these cases of fistula, a foreign body must have been extruded before the operation.

The foreign bodies found in anal fistulae vary. Fish bones are the usual objects found, although seeds, toothpicks, pieces of metal or wood are also found at operation. A sewing needle was found in one of our cases reported here.

Some men have the habit of chewing on a toothpick while conversing. The toothpick is often unwittingly broken and parts of it swallowed. Months later, the individual may present himself to his physician with a perianal abscess and subsequent fistula. He is amazed when the surgeon informs him of his findings at operation. This happened in one of our cases.

Perardi[17] reports a similar interesting case. A patient with a large ischiorectal abscess came to him for treatment. On incising the abscess and evacuating the pus, there was found at the base of the abscess cavity a small piece of wood one inch long with a pointed end. On being questioned, the patient stated that he was a tobacco chewer, but when out of tobacco, he had the habit of chewing on pieces of wood, and occasionally he would unintentionally swallow small bits of it. No doubt he terminated this pernicious habit after this unexpected result.

CASE REPORT

Of the five cases in our series in which the patients were operated on for fistula and in which foreign bodies were found, a toothpick was recovered in one, a calcareous object in another, fish bones in two, and in another patient, a sewing needle.

I shall report this last case in detail because of its interest.

R. C. was a single woman, twenty-one years of age, who for the three months prior to admission to the hospital had pain in the left buttock with a discharge of pus in this area. Examination disclosed the following: On the medial aspect of the left buttock, in the left posterolateral perianal area, 15 cm. from the anal verge, was the external opening of a fistula. The internal opening was located posteriorly at the anorectal line in a crypt. A deeply situated, indurated, cord-like structure

extended from the external opening to the internal opening of the fistula. At about the center of this fistulous tract, 2.5 cm. from the anus, there was felt a fluctuating mass, about 2 cm. in diameter, evidently an abscess.

The fistula was probed, and with the probe in position, an attempt was made to dissect out the whole fistulous tract threaded on the probe. However, when the abscess was reached, the dissecting scissors cut through it, so that the abscess walls had to be dissected out separately. In the bed of this abscess there was found a rusted sewing needle 5 cm. long. The "eye" part of the needle was missing. The whole fistulous tract, abscess walls and all necrotic tissue were completely excised. Complete healing occurred in twelve weeks. X-ray examination of the region failed to show any trace of the missing "eye" part of the needle.

The question here arises as to how the needle got into this location. It is highly improbable that the patient had swallowed it. Interrogation of the patient failed to elicit any adequate explanation. She did not remember having ever felt any sticking sensation in this area.

CONCLUSIONS

1. Simple fistula-in-ano occurs comparatively infrequently in general hospitals, being met with in less than 1 per cent of all admissions.

2. In hospitals devoted solely to tuberculosis, the incidence of fistula is much higher varying from 6 per cent to over 11 per cent of hospital admissions.

3. Tuberculous anal fistula is found only in individuals who harbor a primary source of tuberculosis elsewhere in the body, usually the lungs, and is encountered in general hospitals in about 2 per cent of all anal fistulae. However, in tuberculous subjects, the majority of fistulae and perianal abscesses are in themselves tuberculous in

character as a result of secondary infection with the Koch bacillus.

4. Demonstrable foreign bodies found at operation for anal fistula are few in number, being recorded in only 0.9 per cent of our series of over 500 cases of fistula operations.

5. Although the operation for anal fistula is not a "formidable" one, yet, the surgeon undertaking the operation should be well informed about the anatomical considerations and well versed in the surgical principles involved.

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THE RIGHT LATERAL RECTUS INCISION IN ACUTE APPENDICITIS

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IN recent years the McBurney incision has been advocated for use in all appendectomies in chronic as well as acute and complicated cases.[1] Some would even say that the mortality in appendicitis has been markedly reduced by its use, but the mortality is in the complicated cases and the writer seriously questions the advisability of the general use of the McBurney incision in them. The right lateral rectus incision has been known by many names such as Battle, Jalaguier, Kammerer and Lennander.[2]

The position of the base of the appendix is usually below McBurney's point which is about halfway along a line from the anterior superior iliac spine to the umbilicus. The base of the appendix is usually at the level of the anterior superior spine at the linea semilunaris. Most appendix surgery is done in this region and consequently the nearer the middle of the incision is to this location the better.

The right lateral rectus incision fulfills this desideratum more completely than any other. It is a slightly oblique incision just lateral to the lower right rectus muscle or just over the lateral edge of the muscle through the rectus sheath; then using some slight displacement of this muscle edge mesially, the posterior sheath is exposed. This is not a muscle splitting incision. The muscle is disturbed only by temporarily retracting the lateral edge mesially, and in closing it resumes its original position between the two layers of fascia. The other great advantage apart from its location is that this incision can easily be extended upward or downward as occasion frequently demands. This is of inestimable advantage in complicated cases. It is also of advantage

should the diagnosis be inaccurate and should other organs have to be investigated. It also has the advantage of giving the best exposure to the blood supply of the appendix. Moreover, the site of this incision is more readily accessible to the omentum especially if this structure is short. The right paracolic gutter is not disturbed. Less tissue planes are opened up than with any other incision. A firmer abdominal wall results because the intact rectus muscle is interposed between the fascia layers. There is no injury to nerves or blood vessels. The site is well adapted to the use of local anesthesia as the rectus sheath offers a suitable enclosure for depositing the anesthetic solution. The nerves are small and relatively terminal. The elimination of forceful retraction also recommends this incision both for local and spinal anesthesia especially the elimination of forceful traction on the cecum. The incision is over the usual location of complications. Drainage tubes pass more directly to the stump of the appendix and to the pelvis especially when the full, right lateral (three-quarter prone) position is maintained postoperatively.

Contrary to previous teaching the appendix does not usually point up and in toward the spleen. The postcecal and retrocolic positions are by far the commonest, amounting to over 65 per cent. The next most common locations amounting to some 30 per cent are those which hang over the brim of the pelvis.[3] Consequently, complications are met with behind and below the cecum and to the inner side, at least those short of fully developed abscess. When peritonitis is present, the location of the cecum and appendix is most difficult to determine but the patient can usually

point to the location of the appendix except perhaps in cases which have been allowed to wait too long. Secondary abscesses are some evidence that the lateral incisions have been followed by right inguinal and incisional hernias[6,8] (including bulgings).
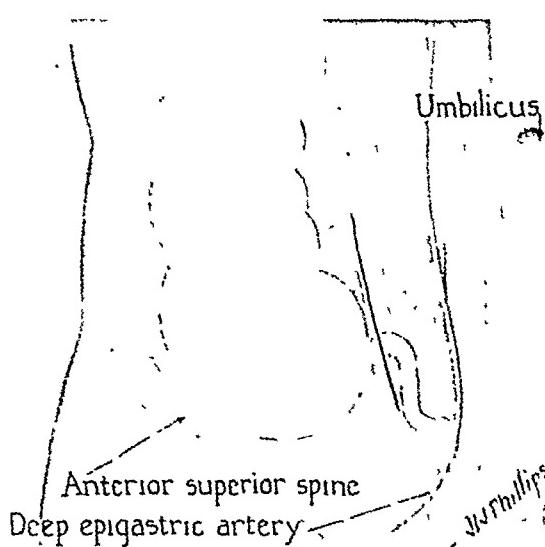
Fig. 1. The incision is made over the lateral border of the rectus muscle, with the mid-point on a line between the umbilicus and the anterior superior spine.
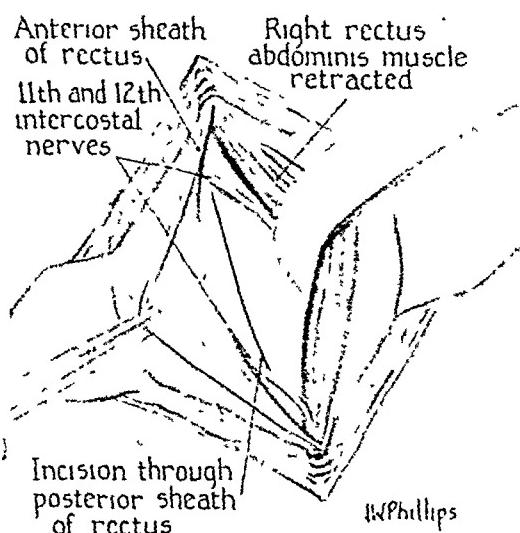
Fig. 2. Showing the muscle retracted medially and the incision through the posterior sheath of the rectus muscle between the eleventh and twelfth intercostal nerves.

usually first located in the pelvis because the initial spread is in that direction. In many complicated cases the appendix and cecum are bound down and friable. This will not permit much in the way of traction should a laterally placed incision have been used. The usual location of the appendix is "down and in."[4,5] The incision, therefore, giving best exposure in these directions is preferable.

As to the question of facility for conducting the operation, the incision described probably necessitates less in the way of assistance than the so-called muscle splitting or cutting incisions because little in the way of retraction is necessary. Better direct visualization, especially of the meso-appendix, can be had with this incision and the pelvis can be more easily reached.

Injury to a terminal intercostal nerve only rarely occurs because the operation can usually be accomplished between two of the intercostal nerves (eleventh and twelfth) going to the lower rectus. Occasionally, one nerve has to be cut but the writer has never seen any demonstrable rectus muscle paresis following. This is of definite advantage because there is

In infected cases with drainage this occurrence seems to be as common in one as the other, especially when one realizes that the right rectus incision has been used in the older age groups.[7,8,9] Apparently statistics compare only the right rectus muscle "splitting" incision.

With regard to drainage with the right lateral rectus incision, the postoperative posture of the patient is most important. Some claim that a full prone position is necessary to lower mortality,[10] and others believe a laterally placed drain is necessary. The fully prone position is very uncomfortable and laterally placed drains are not very efficient in draining over the brim of the pelvis. It has been proved that drainage of the pelvis and of the iliac fossa can be accomplished by a full right lateral position or an incomplete prone posture.[11] This has been used for twenty-four to forty-eight hours after operation with a soft noncollapsible rubber tube as drain. This right lateral rectus incision has been used in fifty consecutive cases of ruptured appendix with drainage, with a mortality of 4 per cent.[12] One of the two

patients lost was eighty-four years old. Only one incisional hernia has appeared over a period of almost seven years and that in an obese woman of sixty-four who had much secondary wound infection. In five cases the whole chromic fascia suture line was removed postoperatively because of infection with no apparent adverse effect on the scar. There were no cases with mechanical obstruction and none with secondary abscess.

The right lateral rectus incision is recommended for cases in which there is an acute condition of the appendix especially in which some complication is suspected.

SUMMARY

In recent years the McBurney incision for appendectomy has been recommended highly. Its advantages are unquestioned but its disadvantages suggest themselves when the advantages of the right lateral rectus incision are considered especially in acute cases which may have developed complications. Moreover in those acute cases in which the diagnosis is not completely clear and in those so-called chronic cases in which some exploration may be desirable at operation, these advantages become even more apparent. The right lateral rectus incision is more directly over the site of the appendix, the meso-appendix and localized complications. The incision avoids damage to anatomical structures; it lends itself to extension readily in either direction; it permits a firm closure even when drainage has to be employed and it facilitates the operative procedure.

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EXTRAUTERINE FIBROMYOMAS

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FIBROMYOMAS, pure myomas and pure fibromas not directly connected with the uterine musculature, are exceedingly rare, there being only about 250 cases reported in the literature to date. In order of most common occurrence they may be located in the vagina, either in the posterior or anterior wall, in the broad ligament of the uterus or in the round ligament of the uterus. (A fibromyoma in the vagina and two in the broad ligament, one of which had undergone sarcomatous degeneration, will be presented.)

There have been several theories advanced concerning the etiology of this type of tumor, all of which have some logical and some illogical points of reasoning. It is necessary for fibromyomas to be derived from some anatomical structure which is made up of both connective tissue and smooth muscle. This anatomical structure is one which usually is very vascular. The statement has been made that fibromyomas of the uterus actually arise from the walls of blood vessels and arrange their fibers of smooth muscle and connective tissue in whorls to simulate the histological structure of a blood vessel itself. Hence, they are extremely common in the uterus which has a rich blood supply.

Some authors state that fibromyomas of the vagina are derived from remnants of the Müllerian and Wolffian ducts. This is quite possible, although since these embryological structures consist of both mesoderm and ectoderm, tumors arising from them should contain some glandular tissue which is not usually the case. This theory would not account for tumors which were in no way connected with these two above named structures.

Grossly, these tumors vary in size from a microscopic structure to quite large tumors. They are usually hard to palpation and yellowish to pearly white in color, just as fibromyomas of the uterus. The consistency depends upon the relative amount of fibrous tissue and smooth muscle composing the tumor. They are usually discrete and well encapsulated. Histologically, they consist of fibrils of connective tissue and smooth muscle closely interwoven with one another and tend to form whorls of tissue. The cells are usually of similar size and shape and present no mitotic figures, making them primarily a benign tumor.

The fate of these tumors, like those of the uterus proper, is varied. Most commonly they remain as benign structures which may attain a large size. They may undergo necrosis due to impaired blood supply and this necrosis almost always begins in the center portion of the tumor. Some undergo hyalinization and even calcification. From an x-ray examination, one such tumor in the anterior vaginal wall was mistaken for a large calculus in the urinary bladder and the bladder was opened for the removal of the calculus. Like those fibromyomas of the uterus proper they may undergo sarcomatous degeneration in which case they become extremely malignant and metastasize rapidly.

The symptomatology of extrauterine fibromyomas varies greatly with the location and size of the tumor. For the most part they produce pressure symptoms. Probably the most consistent symptom of anterior vaginal wall fibromyomas is that of partial and in some cases complete obstruction of the urethra. In the vagina they commonly become ulcerated and produce a bloody, purulent discharge and quite frequently may be mistaken for menorrhagia or metrorrhagia. Some patients will first complain of dyspareunia. Those rising from the various ligaments of the uterus and attaining a large size present a difficult

diagnostic task and due to their rarity are usually thought to be ovarian tumors.

CASE REPORT OF VAGINAL FIBROMYOMA

CASE I. Mrs. F. S., age forty-seven years, was referred to us with a diagnosis of a cystocele. She complained of soreness and pain in the vagina, particularly when in a sitting position. She stated that for the past four years she had noticed a mass protruding from the vagina. The mass had made a gradual increase in size during the four year period until on the date of admission it was about the size of a large orange. Her menstrual periods, four months prior to admission, had always been normal but since that time her periods had increased in duration up to two weeks although the daily flow was no more profuse. For the past two months she had had a leukorrhea and dyspareunia. She had noticed burning on urination and during the last week had noticed a partial obstruction to the flow of urine. Obstetrical history revealed that there had been no pregnancies. Past illness and family history were of no significance.

Physical examination revealed a well developed, well nourished, white female, appearing to be about forty-five to fifty years of age. The head, neck and chest were essentially negative. The abdomen was essentially negative except for moderate tenderness over the region of the urinary bladder. On vaginal examination inspection revealed a mass bulging from the introitus which was covered with a leathery appearing vaginal mucosa. This mass was pear-shaped, with the apex near the urethra. It had the general appearance of a cystocele. To palpation the mass was moderately firm and slightly moveable. The mucosa covering the mass was rather leathery to palpation. Due to tenderness on manipulation of the cervix, the body of the uterus was not palpable. Later, under ether anesthesia, the cervix and body of the uterus were apparently normal to palpation. On rectal examination the mass was palpable. Since a bladder tumor was considered, a cystoscopic examination was made which revealed the bladder mucosa to be normal. The urinalysis was essentially negative, showing only a one plus albumin. The blood count revealed a 70 per cent hemoglobin, a red blood count of 4,100,000, a white blood count of 6,750 with 76 per cent polymorphonuclear leukocytes. A diagnosis of a cystocele or a tumor of the vaginal wall was made.

Under ether anesthesia an incision was made through the mucosa of the anterior vaginal wall directly over the mass. On dissecting back the mucosa a firm, perfectly round tumor mass about the size of a large lemon bulged into the operative field. It was well encapsulated and easily enucleated except for a small pedicle which was adherent to the fascia surrounding the urethra. This pedicle was ligated and severed and the tumor removed.

The pathological report stated that the tumor measured 6 cm. in diameter. It was firm and the cut surface was pearly white in color. Histological examination revealed many connective tissues and smooth muscle fibers arranged in parallels and in whorls. The comparative amount of smooth muscle and connective tissue was about the same. All cells were approximately the same shape and size and no mitotic figures were seen. The pathological diagnosis was fibromyoma. The patient made a satisfactory recovery and has had no similar complaints since the removal of the tumor.

CASE REPORTS OF FIBROMYOMA OF THE BROAD LIGAMENT

CASE II. Mrs. D. B., age sixty-six years, was admitted complaining of abdominal pain. She stated that her first symptoms began six months prior to admission at which time she began to have nocturia and a feeling of pressure in the abdomen, being more pronounced in the lower left quadrant. About two weeks following the onset of her symptoms she noticed a small mass just above the symphysis pubis just slightly to the right side of the midline. For the past three months the mass had made a rapid increase in size until at the time of the first examination the tumor mass almost filled the entire abdominal cavity. Although she was not certain, she believed that she had lost a few pounds in weight within the last month. Her history revealed that she had begun her menstrual periods at twelve years of age and passed a normal climateric at fifty-one years of age. She had had five children, all being normal deliveries. Her family history revealed that her mother died at the age of seventy-six years from a carcinoma of the body of the uterus.

Physical examination revealed the blood pressure to be 210/110, pulse irregular, heart rate 102, temperature 99.2°F. The head and neck were essentially negative for any pathological condition. There was no cervical ade-

nopathy. The heart was markedly irregular and the heart tones were accentuated both on the right and on the left sides. The abdomen presented a large, hard, nodular mass which arose from the pelvis and extended to a point 3 cm. below the left as well as the right costal margin. The mass was apparently fixed to the posterior parietal peritoneum. Vaginal examination revealed a large, hard and nodular mass which completely filled the pelvis. A diagnosis of a fibromyoma of the uterus or a retroperitoneal malignancy was made.

Under ether anesthesia a midline incision was made from the symphysis pubis to the umbilicus and an exploration of the abdomen revealed a large, hard, nodular, tumor mass which completely filled the abdominal cavity and extended deep into the pelvis. Throughout the tumor mass were many cystic areas which varied greatly in size. The deeper pelvic portion of the tumor was firmly adherent to the surrounding tissues, namely, the sigmoid colon, both the right and left ovaries and the body of the uterus. When the adhesions were freed the mass was found to arise from the base of the right broad ligament. The tumor mass was enucleated with difficulty and removed, and due to the rupturing of several of the smaller cystic areas above described closure was made with drainage. The patient made an uneventful recovery during her two weeks in the hospital.

The pathologist stated that the tumor consisted chiefly of connective tissue and smooth muscle fibrils arranged in whorls. The smooth muscle fibers were myxomatous in character. Throughout the sections were large polychromatic and hyperchromatic type of fixed cells with many mitotic figures. A diagnosis of a fibrosarcoma arising from a benign fibromyoma was made.

Six months following dismissal from the hospital she returned complaining of a cough and a marked loss of weight. Her cough was productive and the sputum frequently contained bright red blood. She died one month later from pulmonary metastasis as shown by x-ray examination.

CASE III. Mrs. J. H., age forty-nine years, was admitted and gave a history of having had a menorrhagia for the past two years. On various occasions her menstrual periods had lasted for two or three weeks, during which time she always passed a large quantity of clotted blood. She stated that her last menstrual period,

which had lasted for three weeks, had occurred about five or six months prior to her admission to the hospital. Since that time she had had no hemorrhages until two weeks before admission she had a sudden hemorrhage which lasted two days. The bleeding consisted chiefly of clotted blood. Since the last hemorrhage she had had a great deal of lower abdominal pain and had felt extremely weak. She also complained of low back pain. Her past history and family history were essentially negative. Her obstetrical history revealed that she had delivered five normal, full term children, following which time she had had a miscarriage during the first trimester of her last pregnancy.

Physical examination revealed a rather obese, white female who gave the general appearance of being very anemic. Her head and neck were essentially normal except for oral palor. Her heart presented no apparent enlargement and no audible murmur. Her breath sounds were clear and there was no dullness to percussion. There was rather marked tenderness in both lower abdominal quadrants. Due to the extreme obesity of the abdominal wall no masses were palpable. Vaginal examination revealed a cervix which was rather large and hard. There was a mass in the pelvis which was wedged into the cul-de-sac of Douglas and seemed to extend to the right side. The red blood count was 3,250,000 with a 68 per cent hemoglobin. The white blood count was 10,500 with 69 per cent polymorphonuclear leukocytes. A diagnosis of fibromyoma of the body of the uterus was made.

Following a blood transfusion of 500 cc. of blood and under ether anesthesia a midline incision was made in the lower abdomen. Exploration of the pelvis proved the body of the uterus to be extremely firm, pearly white, regular in outline and slightly enlarged. Both ovaries were somewhat atrophic. At the base of the right broad ligament there was a hard, regularly outlined, egg-shaped mass which was in no way connected with the body of the uterus.

Following the removal of the right Fallopian tube and ovary, the two peritoneal layers of the broad ligament were separated. The right ureter and uterine artery were found to be firmly adherent to the mass described in the broad ligament. After dissecting the ureter and uterine artery free the mass was removed. It was thought that removal of all ovarian tissue

would eventually cause a cessation of the bleeding from the fibrous uterus so the left Fallopian tube and ovary were also removed. Closure was made without drainage. A postoperative diagnosis of fibrosis uteri and fibromyoma of the right broad ligament was made.

The pathological report stated that the fibrous mass removed from the right broad ligament was a fibromyoma which measured 5 cm. in diameter. The patient made an uneventful recovery and at the present time is well.

SUMMARY

1. Extrauterine fibromas, myomas and fibromyomas are extremely rare.

2. The etiological theories and literature have been reviewed.

3. Three case reports of extrauterine fibromas have been presented, one in the broad ligament which had undergone sarcomatous degeneration, one in the broad ligament which was benign and one in the anterior vaginal wall connected to the distal portion of the urethra and large enough to cause marked urinary symptoms.

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THE essential in treatment of . . . rectal and anal abnormalities is to establish a continuity of epithelium between the rectum and skin and thus prevent scar formation and constriction. To provide adequate anal control, the external sphincter muscle must always be utilized.

From—"Abdominal Surgery of Infancy and Childhood"—by Ladd and Gross (W. B. Saunders Company).

ADENOMYOMA OF THE STOMACH*

HETEROTOPIA OF BRUNNER'S GLANDS PRODUCING PYLORIC OBSTRUCTION
CASE REPORT

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THE presence of aberrant gland tissue in the stomach wall, particularly of pancreatic type, has frequently been reported. However, cases in which gland tissue of the Brunner type is found within the stomach wall, are less frequent and usually occur as small sections of foreign gland tissue which are usually discovered at autopsy or in pathological section, appearing as small adenomas insufficient in size to produce symptoms. The production of a tumor mass sufficiently large to cause pyloric obstruction, is apparently extremely rare. In fact, we have been able to find only one case reported in the American literature.

There is considerable question, too, whether any of these had advanced to the stage of pyloric obstruction capable of producing gastric retention which was actually demonstrated by x-ray prior to detection at operation or postmortem examination. The case reported by Woolsey and Millzner[11] (1928) and later noted by Stout[9] (1932) as a single example of lesion which had progressed to muscle hypertrophy and pyloric blocking, was apparently not so determined until after operation on March 5, 1926, when pylorectomy was accomplished. "Dyspeptic" symptoms had continued intermittently since January 1921, and a posterior gastrojejunostomy without resection had been completed in October, 1922, which had given relief for about one year. Subsequently in spite of excellent function of the gastroenterostomy which was revealed by x-ray, the symptoms increased and exploratory laparotomy, accomplished in March,

1926, finally revealed the prime etiological factor as an adenomyoma about 4 cm. prepyloric on the anterior wall of the stomach containing mucosal tissue of the Brunner type.

Several other authors have reported cases of adenomyomas of the pyloric end of the stomach. Magnus Alsleben[5] (1903) reported five cases detected at autopsy all of which revealed small glands connected at some point with Brunner's glands of the submucosa. Gruzdeff's[3] (1909) case is said to be the first adenomyoma to be observed clinically and at operation revealed a mass imbedded in the posterior wall of the stomach near the pylorus which on section proved to be alveoli, lined with stomach type of mucosa but apparently closed cavities without connection with the stomach epithelium.

Others, among them Stewart-Taylor[8] (1925), Ramirez-Corria[7] (1926) Hilarowitz[4] (1927) and Wholwill[10] (1929) have all described cases seen either at autopsy or at exploratory operation which revealed small adenomyomas in the pyloric region with alveoli frequently of the pancreatic type and less frequently either of the Brunner type or of an undifferentiated character. In all an increase in smooth muscle strands was noted.

Petrowitch and Davidowitch[6] (1933) reported a case from Belgrade of adenomyoma with abscess in a twenty-one year old white male admitted to the hospital with history of diarrhea for two days; temperature 102°F., pulse 120 with tender abdomen, especially on the right side. He was explored through a McBurney incision

and a normal appendix found. The incision was enlarged upward and stomach displayed with difficulty. A dilated pyloric

fully observed at the time of these previous admissions no clue obtained to what now seems to have been the true etiological factor

FIG. 1.

FIG. 2.

FIGS. 1 AND 2. Films taken in 1935 showing a long, rather well formed stomach, the only finding of unusual character being in the somewhat more vertical position assumed by the pylorus.

antrum covered with fibrin and very hyperemic appeared. Suspecting a localized phlegmon, a Billroth II resection with drainage was completed. Specimen revealed an abscess the size of a "nut" containing 5 cc. of pus which cultured staphylococci. Sections showed enlarged fibromuscular structures hyalinized about the abscess with adjacent adenomyomatous tumor tissue.

This is of some interest in that it seems to have been the direct factor which led to the discovery of "neoplastic" changes by x-ray and which actually produced the clinical and radiographic obstruction observed in the patient about whom we are reporting.

CASE REPORT

The case which we are here considering is that of J. S., a waiter, twenty-six years of age, single, who was born in New York City, and who was most recently admitted to the City Hospital on October 23, 1939.

By virtue of the chronicity and prolonged duration of his symptoms, he had previously been admitted to City Hospital on several occasions, and although completely and care-

in his disturbance. At no time did his past or family histories seem to report any abnormalities with the exception of those included in the present illness and which are included in the summary of his case at the time of the most recent admission.

At that instant he was complaining of pain in the epigastrium which he reported to have been five years in duration, and of nausea and vomiting in spells which had continued over a period of seven years. The nausea and occasional vomiting were reported to have appeared at varying intervals, sometimes before, during or after meals, but apparently increasing in severity, and "increasing with psychic stress." After a period of a few months epigastric pain began to be noted which was constant in character and relieved only by drinking of milk. He continued to have this pain for a few years without other incident, until 1934 when he was hospitalized here, because of his complaints of gas pains after meals and constant epigastric pain, nausea and vomiting. X-ray findings at this time were reported as suggesting periduodenal adhesion. He was placed upon a Sippy diet and obtained considerable relief. He was again hospitalized in 1935 for a similar complaint and again obtained treatment of the same character with resultant relief. In 1936, because of reappearance of his similar com-

plaints. X-rays were again obtained with findings reported as entirely negative. His condition suggested a possible chronic appendiceal ity. Of late, milk had seemed to relieve his distress for periods lasting from five to ten minutes, following which the disturbance would

Fig. 3.   Fig. 4.

Figs. 3 and 4. Films taken in 1937. The findings were not suggestive of any organic pathological condition. A comparison with the films of 1935, however, seems to indicate a suggestion of a shortening of the stomach and a shifting of the pylorus over the midline toward the left side.

focus and an appendectomy was performed without appreciable pathology being revealed in the tissue removed. However, he was somewhat improved following this operation, but was readmitted in 1937, not for the complaint referable to the stomach but because of constipation, which was quite difficult to control and readmission was accomplished in order to obtain additional x-ray examination. This was accomplished and no organic pathology found at that time.

About eight weeks prior to his last admission, he began to note the recurrence of his epigastric distress with frequent gas pain, aggravated by meals and most severe during the last six to eight weeks. About the same time he noted some brown vomitus, gradually increasing in frequency and amount, although on no occasion, apparently containing any bloody material. He did, however, note a gradual blackening of the stools beginning about one month before admission and reaching its maximum intensity about two to three weeks later. Following this they returned to their brown color. The vomiting during the past few weeks has been green in color but of diminished sever-

reappear and even awaken him during the night.

At the time of his recent admission October 23, 1939 his temperature was 98.6°F. pulse 84, respirations 19 and blood pressure 122/80.

He was found to be a well developed but somewhat undernourished white male about 5 feet 6 inches tall, and weighing 130 pounds. He appeared somewhat anxious and depressed and frequently held the pit of his stomach with his right hand, though perfectly willing to be up and about the ward. His physical examination revealed normal findings with the exception that he had a somewhat scaphoid abdomen with point tenderness high in the epigastric area and a sense of resistance, but no definitely palpable mass. A right rectus scar, well healed, marked the site of previous appendectomy. No hernia could be detected. He had a hemoglobin of 58 per cent and a red blood count of 3,800,000; white blood cells 7,800, polymorphonuclears 68, lymphocytes 27, transitional 3, eosinophiles 2.

Blood typing was group A International; blood sugar was 100; blood phosphorous 3.63; blood phosphates 4.31; blood Wassermann

negative. Examination of stool shortly after admission was positive for occult blood, but subsequent re-examination was negative ten

entire gastric mucosa was reddened and angry in appearance, and in the mucous lake of the fundus globules of the same white foreign

FIG. 5.

FIG. 6.

FIGS. 5 AND 6. Films taken in 1939, preoperatively. The shortening of the stomach and the shifting of the pylorus to the left is more noticeable than previously, together with a persistent deformity and lack of pliability of the pylorus.

days later. Gastric analysis performed on October 24, 1939 revealed the following:

Fasting	15 Min-utes	30 Min-utes	60 Min-utes
Free—no free hydrochloric	10	15	5
Combined 20	15	35	30
Quantity 25 cc	25 cc.	25 cc.	25 cc.

All specimens were very green with many lumps of mucus which gave a positive benzedrine test for occult blood.

A gastroscopic examination was accomplished on November 20, 1939 with the following findings: The antral mucosa was markedly reddened with a dull, dusky appearance. A small pyloric opening was glimpsed with respiration, but the antrum was marked by active peristalsis and somewhat distorted. White irregular solid material was adherent to the anterior posterior and lesser curvature boundaries at the entrance to the antrum. The

material were seen. The impression obtained was that of distortion of pylorus and antrum, marked superficial gastritis and some retention of solid foreign material.

A gastrointestinal series begun on October 26, 1939 showed the stomach to be of orthotonic type revealing along the lesser curvature and prepyloric region a projection of the outline which was irregular and through which no peristaltic waves passed. Near this a little barium collection indicated some degree of irregularity. The pyloric canal was elongated and rather stiffened. The cap was not well visualized. At six hours motility study showed marked gastric distention with food particles in the stomach. The head of the barium column was in the left half of the transverse colon indicating hypermotility. The tail was in the terminal ileum. This was considered evidence of an organic lesion in the prepyloric portion of the stomach with involvement of the pyloric sphincter. Because of location of the lesion a neoplastic condition had to be considered. In any event the lesion had interfered with the motility of his stomach and was causing partial

obstruction. At the end of twenty-four hours, re-examination revealed a gastric retention which had a mottled appearance. This was sug-

wall, about 6 cm. prepyloric appeared to be somewhat elevated and had the reddish discoloration similar to that seen in capillary

FIG. 7.

FIG. 8.

FIGS. 7 AND 8. Films taken postoperatively show complete removal of the pars pylorica and a portion of the duodenum, displaying a well functioning gastrojejunostomy.

gestive of either polyposis or retention of food. A re-examination accomplished on November 15, 1939 revealed a widening of the pyloric canal with the patency of the pylorus apparently fixed, and suggested the possibility of a hypertrophic pyloric sphincter, although the fixation did incline one toward the suggestion of infiltration, not necessarily on the neoplastic basis, as an old ulcer could have been capable of producing these findings.

Throughout the stomach there were translucent shadows circular in outline about the size of a marble which could be displaced from one part of the stomach to the other.

These apparently represented foreign bodies, and suggested balls of mucus that had been swallowed. The findings on this occasion were indicative of hypertrophy of the pyloric sphincter, fixation of the pyloric canal, which in all probability was due to an old infiltration secondary to an ulcer. There was moderate degree of obstruction caused by this condition, inasmuch as at six hours there was still considerable material in the stomach.

In view of these findings exploratory laparotomy was performed on November 28, 1939 with preoperative diagnosis of "chronic peptic ulcer, with secondary obstruction." On visualization of the stomach, an area on the anterior

hemangiomas upon the skin surface. Palpation revealed some thickening of the wall at this point to about four times the normal. This thickening extended for considerable distance beyond the area of coloration. In view of its neoplastic characteristics it was deemed advisable to resect the distal half of the stomach, this being done with the use of a Von Petz clamp, a gastrojejunostomy being performed with the stoma at the lower end of the line of resection. Following operation the patient had a mild postoperative course for four days when rather suddenly his temperature flared to 104°F., pulse to 110, and respirations 28. This began in the evening of the fourth postoperative day and by the morning of the fifth postoperative day temperature had come gradually down to normal levels.

There had been slight pain in the operative area during this time and a few rales were detected at both bases. In the afternoon of the seventh postoperative day temperature again suddenly rose to 105°F. There was complaint of extreme abdominal pain with sufficient evidence of peritoneal irritation to suggest the possibility of breakdown of the anastamosis. Exploration was suggested by some of the staff members, even though evidence existed in the respiratory passages which was felt sufficient to

account for the disturbance. A throat culture taken at this time was negative for pneumococcus, and revealed principally staphlococci. A blood culture taken at the same time was

Here a granular mass protruded into the lumen. The wall of the stomach in this area was markedly thickened. The mass described sectioned with great difficulty.

FIG. 9. Represents a photograph of the gross specimen. At the margin where the instrument is attached, there is a rather marked thickening of the wall of the stomach, particularly at those areas from which sections have been removed. It is possible to discern the hemorrhagic character of the serosa adjacent to the thickened regions.

also negative. Patient was placed on sulfanilamide therapy and within forty-eight hours his temperature had returned to approximately normal levels. Shortly thereafter the patient was placed upon a soft diet and except for an occasional feeling of fullness in the epigastrium he had no complaint. Re-examination of the stomach by x-ray on December 15, 1939 showed complete removal of the pars-pylorica and portion of the duodenum with an enterostomy opening connected with the jejeunum. Barium was leaving the stomach slowly through the stoma but at the six-hour period the stomach had completely emptied.

The specimen of resected stomach measured 10 by 6 by 5 cm. The serosal surface was smooth and glistening throughout except for a well demarcated, raised, moderately firm hemorrhagic area. On opening the specimen the mucous membrane appeared normal throughout except in the region of the raised hemorrhagic area described on the serosal surface.

The microscopic section revealed a normal gastric mucosa moderately infiltrated with lymphocytes and plasma cells above a hyperplastic muscular coat. These were imbedded within the muscular coat and just beneath the serosal coat was noted a well encapsulated area of gastric mucosa surrounded by hyperplastic Brunner's glands.

A diagnosis was made of "Heterotopia of the duodenal mucosa (Brunner's Glands) and chronic gastritis."

Following his discharge from the hospital, the patient maintained a diet of frequent small meals and by January 20, 1940, had gained fifteen pounds in weight, remaining entirely symptom free.

It is naturally rather difficult to reveal in still photographs of x-rays all of these findings which are noted in fluroscopic examination and revealed by manipulation of tissues under examination. However, there

are several findings of interesting character which reveal themselves in a few chosen films which are displayed in the accom-

pathology. A comparison with the previous films, however, seems to indicate a suggestion of a shortening of the stomach, and a

FIG. 10.

FIG. 11.

FIGS. 10 AND 11. Photomicrographs of the center of the involved regions displaying the enfolded stomach mucosa, surrounded by the glands of the Brunner type, which in turn lie within a markedly thickened layer of muscular fibers.

panying diagram. Figures 1 and 2 represent films taken in 1935; Figures 3 and 4, films taken in 1937; Figures 5 and 6 represent films taken in 1939, preoperatively, and Figures 7 and 8 represent films taken postoperatively. Figure 9 represents a photograph of the gross specimen, and at the margin of the specimen to which the instrument is attached the rather marked thickening of the wall of the stomach is discernable, particularly at those areas from which the sections have evidently been removed. It is even possible to discern the hemorrhagic character of the serosa adjacent to the thickened region. Figures 10 and 11 represent photomicrographs of the center of the involved region, displaying the enfolded stomach mucosa surrounded by the glands of the Brunner type, which in turn lie within a markedly thickened layer of muscular fibers.

The x-ray films show in 1935 a long, rather well formed stomach, the only finding of unusual character being in the somewhat more vertical position assumed by the pylorus. In 1937, the findings were not suggestive of any organic

shifting of the pylorus over the midline toward the left side. This seems to be even more noticeable in the films taken in 1939, and together with the persistent deformity and lack of pliability of the pyloric end of the stomach, make up the most significant changes revealed in the plates themselves. Figures 7 and 8 represent the findings postoperatively and display the functioning gastrojejunostomy.

SUMMARY

A case of adenomyoma of the stomach, containing glands of the Brunner type and producing a tumor of the pyloric antrum which eventually led to obstruction and twenty-four-hour retention, is here reported. It follows in large part the characteristics demonstrated by other cases of similar type previously reported, namely, age incidence which seems to indicate a preponderance in young adults, the symptomatology which usually is indicated by gastric distress, nausea and even vomiting of chronic type in addition to absence or late appearance of x-ray evidence for

lesions which, by most pathologists, are considered to be developmental aberrations and, therefore, have probably existed in these areas over the entire lives of the involved individuals. Their clinical appearance and severity of symptoms seem to be in proportion to the overdevelopment of muscle fibers surrounding these lesions.

Special acknowledgment is due the kind co-operation of the late Dr. George J. Plehn, who carefully observed the entire series of x-rays and to Dr. James R. Lisa, who classified the tumor and assisted in the preparation of the section and photomicrographs.

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DURING the acute stage of poliomyelitis, it is not infrequent to encounter urinary retention, especially in adults. This is usually a transitory affair and can be alleviated by sterile catheterizations. After operations on the back or hip, urinary retention may complicate the postoperative course.
From—"Infantile Paralysis: Anterior Poliomyelitis"—by Lewin (W. B. Saunders Company).

OBSTETRICAL ANALGESIA IN PRIVATE PATIENTS

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THE use of drugs to produce analgesia and amnesia in labor has become increasingly popular. On the other hand, there is a distinct movement in the opposite direction supported by quite a number of experienced obstetricians. However, it is pretty generally agreed that the amelioration of pain during labor is desirable although the ideal analgesia is yet to be evolved. There are at the present time several methods that are reasonably satisfactory although none is entirely foolproof.

Common usage interprets the word analgesia to mean both a lessening of pain and loss of memory. This, of course, is not strictly correct, but will be used in this sense in this paper. Analgesia is an adjunct to obstetrical technic, not a panacea for many of its complications. When analgesia is resorted to, particular attention should be given to the occurrence of premature separation of the placenta and less frequent pathological conditions since they may be obscured by the use of drugs. The attending physician should be doubly watchful in order to exercise the best judgment in handling his responsibilities. Therefore, the maternal pulse, fluid intake and output, fetal heart tones, rupture of the membranes, dilatation and effacement of the cervix, engagement and descent of the presenting part should be given close attention. Any marked variation from the normal demands prompt treatment. Analgesia enables the patient to approach delivery with less fatigue than those who have to do without it. This is expressed by the maintenance of a normal pulse rate. This perhaps is due to the fact that the patient is able to sleep and relax between her pains.

I am reporting here 312 consecutive private patients treated during the past three years with nembutal and scopolamine.

These are not routine cases. Frequently patients enter the hospital so far advanced in labor that only anesthesia can be given. I have not included in this series any cases delivered by cesarean section after a trial of labor. Having had experience with practically all other methods of analgesia I have found this combination of nembutal and scopolamine to be the most satisfactory to date. It has been used by me as a preoperative medication for spinal anesthesia for nine years. The state of mental relaxation in which patients came to surgery, and often maintained throughout the entire operation, has impressed me most favorably. Subsequent observations have confirmed this impression in regard to labor. Although nembutal was first used by me in combination with both scopolamine and an opiate, the latter was discontinued. I believe this analgesia to be safe in the hands of any conscientious physician. It can be used in either home or hospital with a minimum of equipment and personnel. I do not intend to discuss the pharmocology of these drugs. Their clinical actions have been carefully observed and recorded and there is nothing further to be added. I have purposely reported this private series in preference to a larger series conducted in charity institutions because inadequate physical facilities in the latter make it impossible to isolate patients and good analgesia is not readily achieved. Furthermore, in some charity institutions the patients pass through so many hands before delivery it is difficult to evaluate the efficacy of a drug.

In deciding to give analgesia one must realize that arguments have been raised against its use, especially those drugs that may cause apnea in the newborn. Schreiber[1] believes that when apnea is

present at birth an anoxemia is produced in the baby which, if prolonged, may cause a focal necrosis of brain cells. If this apnea is not fatal, later in life these children may show evidence of spasticity, have convulsive seizures or be mentally retarded. In his study, however, Schreiber has not considered the rôles of dystocia and hard forceps delivery, or the use of oxytoxics, any of which may result in cerebral hemorrhage, a recognized cause of apnea. Clifford and Irving[2] have shown that anesthesia may cause apnea in the newborn, especially when nitrous oxide-oxygen in ratios above 85:15 are used. Their results substantiate the work of Eastman. While the work of Schreiber makes us consider analgesia in a new light still his thesis has not been entirely proved. One must remember that various types of analgesia have been used successfully for many years. Observations by Bill, Irving, Danforth[3] and others upon large series of patients are not in accord with those of Schreiber.

METHOD

In choosing an analgesia several factors must be considered, the drugs used must: (1) be safe for both mother and baby; (2) be reasonably easy to administer; (3) not require special equipment or assistance, and (4) not be prohibitive in cost. I believe this combination meets these requirements and so at the beginning of her last month of pregnancy the patient is given 3 gr. of nembutal to see what her reaction is to this drug. If it produces a good sleep, there will be no contraindication in its use in labor provided she does not have an upper respiratory infection at the time of labor. As soon as labor has been well established, in other words, when the patient is aware of pain, she is given 6 gr. of nembutal by mouth and $^1_{150}$ gr. of scopolamine hypodermically. The capsules of nembutal are punctured at both ends and given with a small amount of tepid water to aid in dissolving them and to provide quicker absorption. The room is

then darkened and as far as possible all external noises are deadened, sideboards are fastened to the bed and an eyemask is put in place. A nurse is left in constant attendance. Usually the patient goes to sleep in from fifteen to thirty minutes. With each pain she will awaken, squirm about and then go back to sleep as the pain ceases. The length of analgesia depends on the rate of oxidation of the drug, severity and frequency of uterine contractions and other factors over which there is no control. Generally speaking, there was no relation between the dosage of nembutal used and the weight of the patient in this series. One dose usually provides relaxation and sleep for four to five hours. If delivery is not imminent, additional medication may be used. It has been my policy to give another 3 gr. of nembutal and if labor is prolonged a third dose of 3 gr. is added. If scopolamine is repeated, I give $^1_{200}$ gr. Only in a few instances was it necessary to resort to opiates in the hope of relaxing a rigid cervix and giving the patient additional rest. The dosages used are shown in Table 1.

TABLE 1
DOSAGE

Drug	Primi-parae	Multi-parae
Nembutal gr. 6 and scopolamine hydrobromide gr. $^1_{150}$	112	81
Nembutal gr. 6 and gr. 3 and scopolamine hydrobromide gr. $^1_{150}$	81	26
Nembutal gr. 6, gr. 3, and gr. 3 and scopolamine hydrobromide gr. $^1_{150}$	8	4
Additional opiate—dilaudid gr. $^1_{32}$	4	3
Additional scopolamine hydrobromide gr. $^1_{200}$..	6	2

DELIVERY

All patients were delivered under ether or gas anesthesia after a routine episiotomy. The cervix was inspected and repaired when found necessary. It is my custom routinely to deliver patients with outlet forceps when the head comes on the perineum. Unquestionably, more of these

cases would have delivered spontaneously had I chosen to wait. The methods of delivery are shown in Table II.

TABLE II
METHODS OF DELIVERY

Delivery	Primi-parae	Multi-parae
Spontaneous	49	69
Outlet forceps	133	26
Mid forceps	7	4
Version extraction	0	4
Breech extraction	12	8

RESULTS

In evaluating the effect of the analgesia used here I have classified them arbitrarily as good, fair and poor. While I appreciate that this is not very scientific, I believe nevertheless that they convey a fair meaning of the reaction of the patients. It goes without saying, however, that one might expect better results from the use of this analgesia if the patients could be isolated in a soundproof room and have a trained personnel to observe them. The conditions under which these labors were conducted were not ideal but still reasonably good. The results are shown in Table III.

TABLE III
RESULTS

	Primi-parae	Multi-parae	Per-centage
Good	175	82	82
Fair	16	24	13
Poor	10	5	5

MATERNAL COMPLICATIONS

No deaths occurred in this series. One patient had a moderately severe postpartum hemorrhage four hours after delivery which I believe was in no way connected with the analgesia. She had had a postpartum hemorrhage following her first delivery in which neither analgesia or anesthesia was used. Eight of the patients who were in hard labor over twenty-four hours became very restless and so difficult to manage that seven of them were given an opiate. Each of these eight had received 12 gr. of nembutal and I did not wish to give them any more. One patient had a mild sepsis from a retained cotyledon which subsided when the cotyledon passed spontaneously. One patient developed a severe pyelitis on the sixth postpartum day. She recovered quickly under sulfanilamide therapy. It would not seem that either of these infections was in any way related to the analgesia. All mothers were discharged from the hospital in good condition.

FETAL COMPLICATIONS

One baby was stillborn. This was a breech presentation and death was due to the umbilical cord becoming impinged between the buttocks of the fetus and the sacral promitory of the mother. The fetal heart was not heard before delivery and death was in no way related to analgesia. One baby had an intestinal obstruction requiring surgical relief on the seventh day. He recovered. One baby, delivered by podalic version and extraction, was a mild hydrocephalic and subsequently died at the age of seven months. Twelve babies, 0.4 per cent, showed evidence of asphyxia at birth, six of whom required the use of a tracheal catheter for resuscitation, while the other six responded to carbogen inhalations. Five of these twelve babies were delivered by mid-forceps after long labors which may account for the asphyxia. These twelve cases showed no subsequent evidence of asphyxia. However, there were three other babies who breathed spontaneously at birth and several hours later had attacks of cyanosis. They responded immediately to carbogen and received no other treatment. No further attacks occurred after leaving the hospital. These three babies have been closely followed for over two years and are normal in all respects. While latent attacks of anoxemia following the use of analgesia have been

reported, further investigation is necessary to confirm this hypothesis. A fairly large clinical experience in patients who have had neither analgesia nor anesthesia has taught me that attacks of cyanosis in the newborn are not uncommon.

SUMMARY

1. A series of 312 private cases of labor are reported in which nembutal and scopolamine were used to induce analgesia. Good results were obtained in 82 per cent. Most of the patients failing to respond were in hard labor before analgesia was started and hence the drugs had insufficient time to induce sleep.

2. There were no severe maternal complications in this series. Ten patients were markedly restless and difficult to control. One baby, 0.32 per cent, was stillborn due to a prolapsed cord which was in no way related to analgesia. Six babies were deeply asphyxiated at birth and required the use of a tracheal catheter for resuscitation. Six other babies who showed evidence of asphyxia responded to carbogen inhalations.

CONCLUSIONS

The combination of nembutal and scopolamine, in the dosage described, can be used with safety to induce analgesia in labor. Patients with this type of analgesia require *constant supervision*. The length of the first stage of labor is not increased, the length of the second stage of labor may be increased due to lack of co-operation with the expulsive powers, hence more outlet forceps are necessary. A small percentage of the babies will require artificial methods of stimulation to establish respiration.

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METHYLENE BLUE AS AN INDICATOR FOR THE ORAL ADMINISTRATION OF FOOD TO THE SURGICAL PATIENT

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UNTIL recently, the accepted purpose of surgery was to alleviate pain by the removal of the affected part. Later, it became evident that not only was the part to be removed, but that the re-establishment of normal physiological functions as necessary. This brought about the present evolution of surgery and the appreciation of the fact that the technical procedure was merely an incident in the processes of rehabilitation of the patient. With simplification of laboratory technics, refinements in the preoperative and post-operative evaluation of the patient, have become almost routine. However, as we read the literature of the day, one is impressed with the continuous and deliberate neglect of certain well established principles. Statement of some of these will not be universily accepted; yet their truth cannot be denied. For example, in cases of peritonitis, it is advised not to feed the patient; use morphine freely and keep the patient at rest. An examination of these statements demonstrates a most controversial condition. Lack of food in the gastrointestinal tract is conducive to the production of gas and supsequent distention. Distention interferes with both digestion and absorption, reduces blood supply and osmosis, thereby reducing the normal resistance of the intestinal tract. The theory is that food will increase motility and either reduce resistance or spread infection. Yet we know that there is always residue in the intestinal tract, that a great bulk of the feces is composed of bacterial débris and failure to maintain the proper relationship of certain factors in the lumen permits certain bacteria, which normally

are harmless, to become pathological. The use of morphine again demonstrates the application of known facts. Morphine does not inhibit peristalsis but, on the contrary, brings about a more normal rhythm. That peristalsis is definitely of value is conclusively demonstrated by the use of spinal anesthesia. Most surgeons will admit that it is the anesthesia of choice in general peritonitis. Certainly one cannot argue that the brilliant results are all obtained from the lessening of shock alone. Thus the conclusion is: Certain of the principles now adhered to for postoperative care are groundless. The important factors in the care of such patients are to know definitely that the intestinal wall is completely viable and absorption is normal. Without this information, all methods of care become empirical.

More recently, the brilliant results of so many workers in water balance, high protein maintenance and proper evaluation preoperatively of the patient, established beyond doubt the necessity for proper preoperative physiological preparation of the patient. While these facts are well known and the literature is filled with modern advances, too frequently the application becomes a mere routine with no attempt to evaluate the patient by using the simple laboratory procedures which are now at our command. The free use of infusions and transfusions often burdens an already laboring physiological machine and the reaction becomes too much for the patient; thus we are guilty of aiding a stormy convalescence rather than relieving it. Methods developed to sustain the patient during the reaction period have been
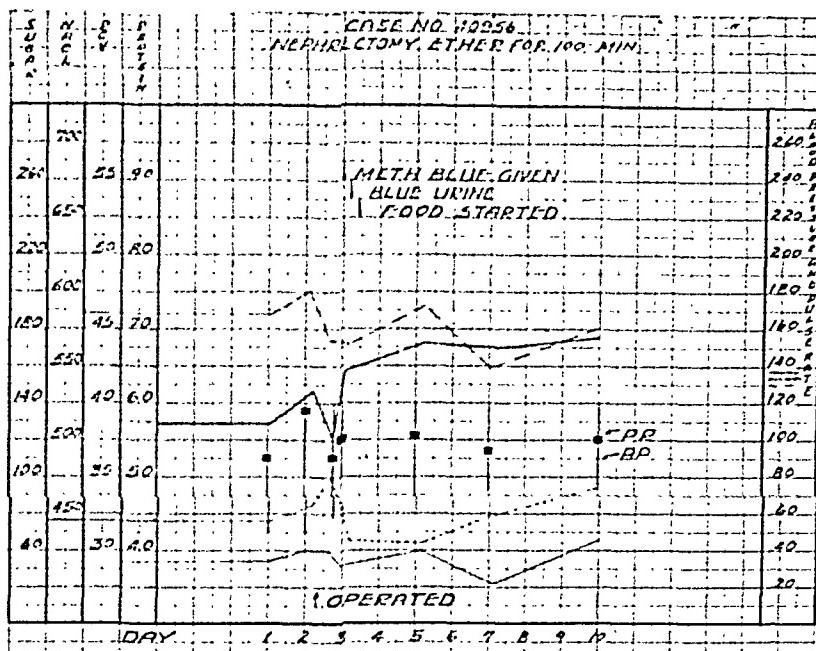
FIG. 1. Case No. 40956. An eighteen year old female, three and one-half months pregnant. She had a nephrectomy for a hydronephrosis. Methylene blue was given about seven hours postoperatively and blue urine was obtained within three hours. Food was started the next morning. The patient did not vomit and had a smooth convalescence. Note the gradual increase in the plasma protein and the packed cell volume during her convalescence. The patient was discharged with pregnancy undisturbed.
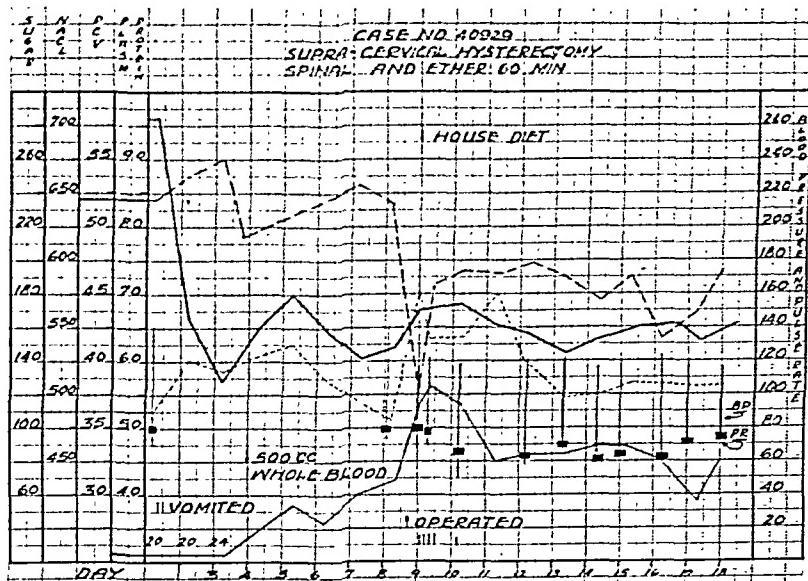
FIG. 2. Case No 40929. A thirty-four year old white female who had had vaginal bleeding for two years. A supercervical hysterectomy was done under combined spinal-ether anesthesia. Before operation she received one transfusion of 500 cc. of citrated blood. Methylene blue was given three hours postoperatively and blue urine obtained in three hours. Food was started immediately. She vomited several times but did well during her convalescence. There was little change in the blood pressure and plasma protein after operation.

demonstrated of moderate value. It still remains apparent that the oral administration of food is the only method of feeding,

possible, how serious, and whether it was complete. A dye seemed the most likely indicator. Methylene blue was the final
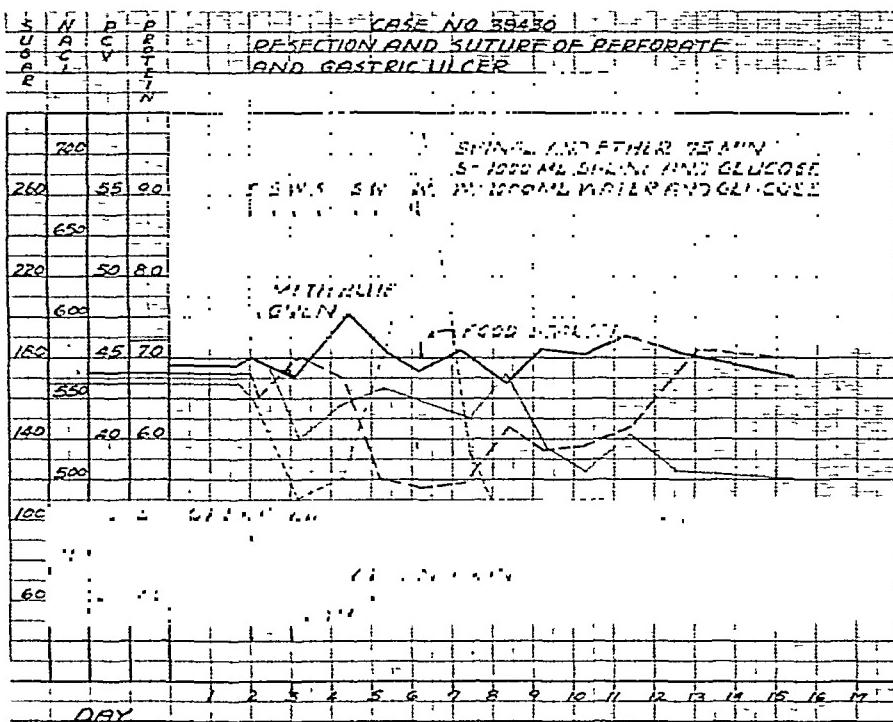
Fig. 3. Case No. 39430. A thirty-six year old white male who had suffered a perforation of a gastric ulcer about six hours before operation. Methylene blue was given the day after operation but no blue urine was obtained until the third postoperative day. In consequence, food was not started and he was given several intravenous injections of glucose and saline. After green urine was obtained he was able to take food without discomfort. He made an uneventful recovery. No further intravenous medication was necessary after food was started.

compatible with normal metabolism. To date, the decision as to when to feed the patient has been based on empirical deductions.

Early in 1928, we started to feed the postoperative patients as soon as nausea and vomiting stopped. We found that there was a marked reduction in postoperative morbidity. However, we were of the opinion that some method could be devised which would give us a physiological basis for this decision. Nausea and vomiting need not necessarily mean that the patient could or could not take food. Our problem was to ascertain that the intestinal tract was absorbing and the kidneys were functioning. An effort was made to find some method to determine, not only these facts, but should there be a break in the chain, if

choice. While little is known concerning absorption and secretion of the dye, it is known to be harmless, and in the quantities used, certainly could not harm the patient.

This preliminary report is based on the observation and study of approximately one hundred patients with all types of surgical procedures. The charts herein presented represent no special cases but rather a diversified group of surgical technics. The dye, 1 gr. in capsules, is given by mouth from six to eighteen hours post-operatively. The patient is requested to void prior to its administration; if he cannot, he is catheterized. At the time of administration of dye, as much water is given as can be comfortably taken. During the next three hours, small amounts of water are given repeatedly. After three

hours, the patient is encouraged to void. If there is failure, he is catheterized at the end of five hours. If greenish-blue urine is obtain this secretion of the dye invariably means a sick patient. Also, a weak color is a signal to go slow with oral feeding.
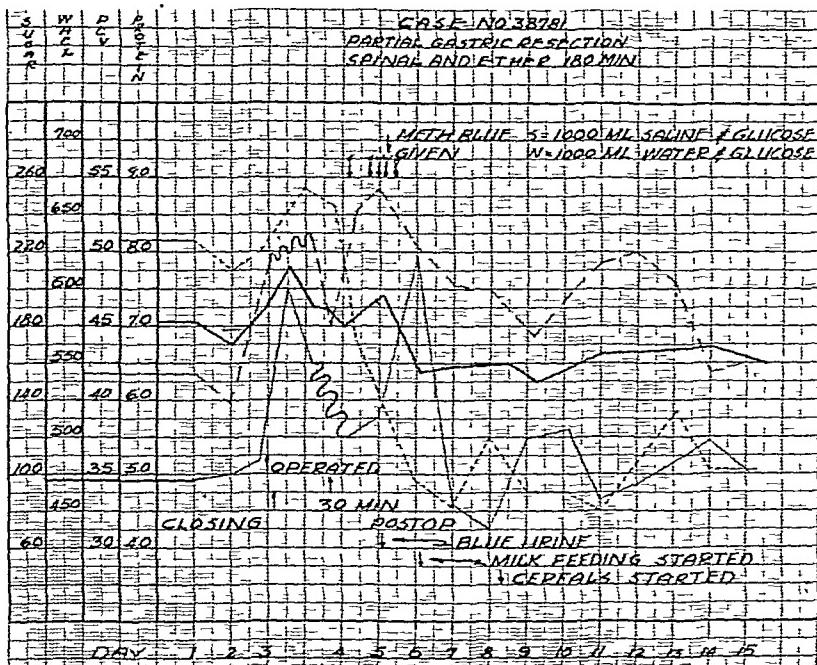
FIG. 4. Case No. 38781. A thirty-three year old male who had had two previous repairs of perforated gastric ulcers. At the time of this operation he was suffering from a partial pyloric obstruction. We call to your attention the marked reduction in packed cell volume and plasma protein caused by the administration of five liters of intravenous solutions over a period of seventy-two hours, not an unusual quantity as these solutions are given routinely today.

Methylene blue was given shortly after operation and blue urine was passed within three hours. As this was one of our first cases, food was not started until sometime later. Notice that there is an almost immediate increase in packed cell volume and plasma protein after food by mouth is started; furthermore, the wide fluctuations in all values tend to be reduced.

obtained, we assume that the ability of the intestines to absorb and the kidneys to secrete, has been established and we proceed to feed by mouth. We know that in chronic cystitis, the color of the urine will wash out rapidly, hence these bladders must be emptied often. It is stated that in certain types of nephritis, the color will not be secreted. To date, this has not occurred in our series and therefore, we cannot comment. Normally, color should appear in the urine in about ninety minutes. Since we believe catheterization should not be encouraged, we seek a specimen in from three and one-half to five hours by voiding. Observation has taught us that failure to

The criticism offered to this technic can be stated that the part operated upon is not sufficiently healed to withstand food and digestion. We believe this is contrary to existing knowledge. Even though a partial gastrectomy has been done, the stomach continues to secrete and the digestive juices to regurgitate. In fact, one of the outstanding methods in the care of the patient with a gastric ulcer is to place the stomach at rest by feeding. We would admonish those who apply this method to use judicious application and feed according to requirements and ability of the patient.

Since the application of methylene blue, we have observed marked reduction in

wound infections, postoperative nausea and vomiting and have almost eliminated the use of the Wagensteen appliance. The accompanying charts illustrates these points.

The values given in the figures are: The thick solid line represents plasma protein as determined by the falling drop method of Barbour and Hamilton; the thin line represents the packed cell volume as determined with the Wintrobe tube; the dotted line represents blood sugar as determined by the Folin-Wu method adapted to the photoelectric colorimeter; the broken line represents blood sodium chloride as determined by modification of Mohr's method.

SUMMARY

We present a rationale for early feeding and the discrepancies of many of the arguments advanced against it.

A method for ascertaining the physiological re-establishment of the absorption of the intestinal tract and the function of the kidneys is presented.

The use of methylene blue, an innocuous dye, as the indicator and the admonition against free feeding without adequate study of the patient are also presented.
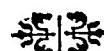
An essential principle in the care of compound fractures is that no treatment of the wound itself should be allowed to interfere with correct splinting.

From—"Wounds and Fractures"—by Orr (Charles C. Thomas).

TENDON INJURIES*

A STUDY OF ONE HUNDRED AND SIXTEEN CASES

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THERE are few fields in surgery that are so prone to produce disappointment as that of the tendons and nerves in and near the hand. Few writers on the subject are satisfied with their own results, but they are encouraged by the increased percentage of satisfactory outcomes which appears to be due to intensive study of the problems involved, and continued experience in the operative technic. As an example of the careful and effective work which is being done on the surgery of the hand, one must mention that of Koch and Mason.[1] They stated, "A few patients have secured a perfect functional result and it is such cases particularly that encourage us to keep on trying to perfect our technique to such a point that we can in fairness hold out to every patient with division of nerves and tendons the reasonable assurance of a satisfactory result." Following are two case reports from our series which serve as a reminder that "it can be done":

CASE REPORT

CASE I.   R. S., a sixteen year old student in a trade school, sustained a laceration on the volar surface of the left forefinger over the proximal interphalangeal joint. Examination showed that no voluntary flexion of the interphalangeal joints was possible, and the diagnosis of section of the flexor profundus and sublimis tendons was obvious. The hand was carefully cleansed, and operation was begun under local anesthesia two hours after the accident. The profundus tendon only was sutured, using the method preferred by Koch and Mason, which will be described below. The finger was maintained in flexion by a light metal splint on the dorsal side, but after two days, this splint was removed daily by the patient, and active motion was

given to the finger. The laceration healed satisfactorily in spite of the fact that the wound lay in the crease where extension tended to open it. The splint was discarded at the end of six weeks. The result at the end of eight weeks is shown in Figure 1. This is a very satisfying result from the suture of a flexor tendon within the finger, a location which gives the poorest number of good results, as will be seen in the analysis of results below.

CASE II.   E. B., was a twenty-eight-year old man who cut his right wrist on the glass of a car window. The following injuries were sustained: complete section of flexor carpi ulnaris, flexor carpi radialis, palmaris longus, flexor pollicis longus tendons, all of the superficial and deep flexor tendons of the fingers, the ulnar artery and the ulnar and median nerves. The operation was done under local anesthesia by Dr. George Wadsworth. All of the tendons except the palmaris longus were united by suturing with silk according to the method of Bunnell. The artery was ligated and the nerves were sutured in the usual manner. The wound healed by primary intention. Active motion was begun during the first week, and after healing had progressed to a safe degree, physiotherapy was used generously. Almost perfect motor function of the fingers resulted, as may be seen from the follow-up photographs in Figure 2, taken fifteen months after the injury. At this time, there was still some impairment of sensation as a result of the nerve injuries.

In this analysis, 116 cases of primary tendon suture were studied. One hundred five of these were in the hand and wrist; the others were in the ankle and foot. Men sustained this injury five times more frequently than women. The age group most frequently involved was that of the third decade. The right and left hands were equally involved. Injuries of the hand

FIG. 1. Case 1. Result obtained following suture of flexor tendon of the left forefinger at the proximal interphalangeal joint.

FIG. 2. Case 11. End result following repair of all of the flexor tendons of the hand.

were encountered a little more frequently than those of the wrist or fingers, and almost two-thirds of the cases involved the flexor tendons.
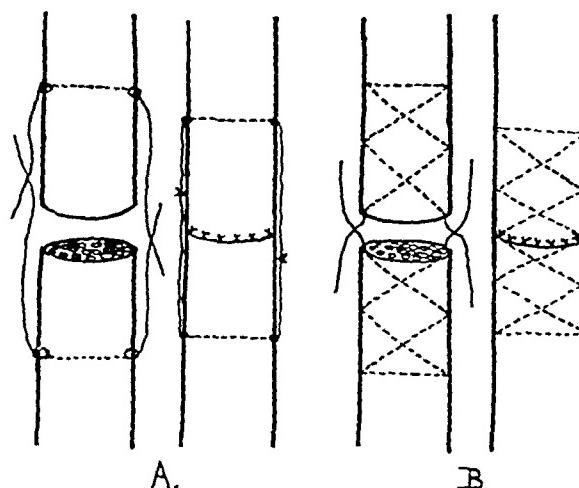
FIG. 3. Methods of tendon suture; A, method recommended by Koch and Mason; B, Bunnell's method. (After Koch and Mason.[1])

Table I shows what the patients were doing when they sustained the tendon injury. The high percentage of industrial cases is undoubtedly peculiar to the Henry Ford Hospital. The industrial injuries were usually of a crushing type, since they were caused by falling machinery, the punch press, rebore and tool machines. Many were complicated by fractures of the metacarpals and loss of skin which created problems of closure and fixation. Household injuries were invariably clean lacerations, produced by knives, razors, porcelain water faucet handles and broken glass. The athletic injuries were subcutaneous ruptures of various tendons.

TABLE I
TYPES OF INJURY

	No. Patients	Per- centage
Industrial	62	53.4
Household	35	30.2
Automobile	14	12.1
Athletic	5	4.3
	116	100.0

Table II shows the results that were obtained when operation was undertaken after various periods of time had elapsed. It is, of course, difficult to define criteria for the classifications of "good, fair, and poor." However, an attempt at classification seems justifiable. The patients with "good" results had hands which functioned adequately with no disability for their work. Range of motion in fingers was from 75 to 100 per cent of normal. Patients with "fair results" had some motion in the involved fingers, but this motion was short of satisfactory and caused some disability. Some of these patients were dissatisfied, and would consent to a second operation if they could be promised better function. Others were well pleased with the status quo. The patients with "poor" results had little or no motion in the involved fingers and most of the original disability persisted.

TABLE II
INTERVAL BETWEEN INJURY AND OPERATION (UPPER EXTREMITY ONLY)

Preoperative Interval (Hours)	Results			
	Good	Fair	Poor	Total Cases
1 to 4	33	15	5	53
5 to 8	6	7	4	17
9 to 12	5	9	9	23

That the duration of a tendon injury preoperatively bears a direct relationship to the end result, has been repeatedly emphasized. Koch and Mason believe that primary repair of flexor tendons of the hand should not be attempted more than four hours after an injury. It is possible to delay longer in the case of extensor tendons, and O'Shea[2] sets his limit at eight hours. Table II shows the remarkably better prognosis with early operation, within four hours, and the inadvisability of operative intervention after eight hours.

Table III shows again the well known fact, that the more distal the cut in the tendon the worse the prognosis. The poor

results from the suturing of tendons within the finger is especially challenging; and when such an injury is encountered, the best hand surgeon available should be enlisted to do the operation. Indeed, the suturing of a flexor tendon anywhere in the hand or wrist is a major procedure, requiring specialized technic and aptitude, comparable to that possessed by ophthalmic and brain surgeons.

TABLE III

RESULTS WITH FLEXOR TENDONS IN THREE LOCATIONS

Location of Injury	Results			
	Good	Fair	Poor	Total Cases
Wrist	14	4	2	20
Hand	7	9	5	21
Finger	2	5	12	19

Table IV shows that it is a different story when one is dealing with tendons on the dorsum of the hand, i.e., the extensors. The tendons may be united by any one of a number of different methods. The loose skin and areolar tissue of the back of the hand permits motion in the presence of adhesions and such adhesions almost always disappear in a year or two.

TABLE IV

RESULTS WITH EXTENSOR TENDONS IN THREE LOCATIONS

Location of Injury	Results			
	Good	Fair	Poor	Total Cases
Wrist	2	3	0	5
Hand	13	7	2	22
Finger	10	4	0	14

Infection. Infection of the wound following tendon suture about the hand is a dreaded complication. The incidence of infection reported by various authors has been rather high. With improved technic and the use of local chemotherapy, a reduction in the rate of infection is to be expected. In Buxton's[2] series, approximately 15 per cent were infected. O'Shea reported an incidence of approximately

13.3 per cent; infection was six times more frequent when catgut rather than silk was used in the suture (one hundred thirteen cases in the series). In the series of Eisberg and Sonnenschein,[4] there were seven infections in fifty-eight cases, or 12.1 per cent approximately. In our series of 116 cases, eleven cases became grossly infected, requiring surgical drainage of suppuration, hot compresses and other surgical attention. Twenty other cases did not heal by primary intention, there being superficial infection of the skin margins. The noninfected cases gave six times as many good results as poor, while the infected cases gave twice as many poor results as good.

Since 1930, silk has been the only suture material to be used in tendon surgery in the Henry Ford Hospital. Previously, some cases were done with catgut. Comparison of the cases done with the two suture materials shows that good results were 40 per cent more frequent when silk was employed. It could not be demonstrated that the type of anesthesia or the clean-up method affected the incidence of infection or the end results. Local and general anesthetics were used with equal frequency.

Tendons of the Foot. These injuries included lacerations of the tibialis anticus tendon, the achilles tendon and the flexors and extensors of the toes. In eleven cases, there were ten good results. These tendons appear to be much easier to deal with than those of the hand.

RECOMMENDED PROCEDURE FOR TENDON SUTURE IN THE HAND

There is nothing original in the operative procedure about to be described. It is essentially the procedure which Koch and Mason have presented many times. The matter of the time interval has already been discussed. Operation should be done within a four-hour period, otherwise the wound had better be sutured and the tendon repaired several weeks later. A painstaking examination of the

hand to determine the total extent of tendon and nerve injuries before beginning the operation is stressed. Such a painstaking examination will take less than five minutes if one is familiar with the anatomy. The hand is washed with tincture of green soap and copious amounts of water for ten to fifteen minutes. The nails are carefully cleaned. The wound itself is irrigated with a liter of saline solution.

The operation is done in a regular operating room, with two assistants for the surgeon, and an instrument nurse, preferably one who is familiar with the operation of tendon suture. General anesthesia is usually preferred, but local anesthesia may be employed. Both of the cases reported in this paper were done under local anesthesia. A blood pressure cuff is used for a tourniquet, in cases in which a general anesthetic is given, thus giving a bloodless field for exploration. The pressure is released every half hour for a short interval.

Needless to say, the operation should be carried out with meticulous attention to the details of atraumatic surgery which have been emphasized by writers on this subject and other aspects of wound healing. One should use sharp dissection when possible. Tissues should be handled with extreme care. Hemostats should grasp a minimum amount of tissue, and they should be replaced by a tie of fine silk cut short.

For the suturing of the tendon itself, we prefer the method described by Koch and Mason, as illustrated in Figure 3. In the diagram, this may not look as effective as the method of Bunnell, since there is more suture material outside the tendon. However, it is easier to apply, and our recent experience is tending to show that it gives the best results. The ends of the tendons are caught with Allis clamps, crushing as little tissue as possible. The ends are matched up, and while the tendons are steadied with the clamp, the main suture is placed, usually with a small curved cutting needle. No. 1 braided silk is used for this suture. As soon as each

suture is placed, the part of the tendon crushed by the clamp is cut away with a brisk stroke of a sharp scalpel, leaving a clean transverse surface for approximation. The corresponding ends are firmly approximated by tying the appropriate tension sutures, after which several interrupted sutures of No. 00 fine silk are placed to complete the repair.

Little can be accomplished in trying to close tendon sheaths. The less silk is left buried, the better. The skin is closed with interrupted sutures of medium silk. The hand is splinted in a position of complete relaxation for the tendons involved, but motion is encouraged and insisted upon after two days. The period of hospitalization varies from none to ten days. Some cases with injuries to extensor tendons are not kept in the hospital after suture. Patients who have had suture of the flexor tendons remain in the hospital about a week, after which they are seen in the outpatient department at two-day intervals. It has been assumed that healing is fairly complete at six weeks.

SUMMARY

1. One hundred five tendon injuries of the hand and wrist and eleven tendon injuries of the foot have been analyzed for factors bearing on the end results.

2. The importance of early operation, avoidance of infection and the use of silk as the suture material has been demonstrated again.

3. The difficulties involved in suturing flexor tendons, especially those of the fingers, have been stressed.

4. Two cases are reported in detail.

5. A summary of the procedure recommended for tendon suture is presented.

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LEUKOCYTE EXHAUSTION IN INTESTINAL OBSTRUCTION*

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LEUKOPENIA has long been known as a constant accompaniment of certain disease processes and as the result of numerous forms of poisoning, i.e., benzol, arsphenamine, radium, etc. Drugs such as sulfanilamide and sulfapyridine have left in their wake isolated instances of marked depression of the bone marrow and numerous hemopoietic disorders display a considerable thinning of the leukocytic stream. The appearance of leukopenia following the release of an intestinal obstruction is an observation which has not been previously noted or reported as one of the findings in the course of a rectified obstruction. It is the purpose of this paper to present a series of cases in which there occurred a marked lowering of the leukocyte level following the release or removal of the bowel obstruction. In the literature blood chemistry studies have been reported frequently from patients who present either a mechanical or a paralytic type of ileus, but accurate hemograms have not been reported on such patients in the early postoperative period when a fall in leukocytes may manifest itself.

Ordinarily, an initial count of the white blood cells is done on the patient's admission to the hospital as a diagnostic procedure, but rarely are the hematologic studies continued or repeated following either medical or surgical treatment, as it has been believed most likely that additional blood examinations are unnecessary as a factor in therapy, apart from their value in complications. Thus the possibility of disclosing a leukopenic state is usually missed and such a hematologic condition goes undiscovered.

In numerous case compilations and collected series the leukocytic changes which we are about to describe, has gone completely undetected. Wangensteen[1] in his monograph states that "Little specific help in the diagnosis of obstruction is obtained in general laboratory procedures. When vomiting has been a prominent feature, concentration of the blood occurs and increased values for hemoglobin, red cells, and leukocytes may be found." And again, "occasionally, leukocytosis may be absent altogether in infection and leukocytosis is usual following trauma, after hemorrhage and processes which cause severe dehydration." No mention is made in the work of the state of the blood in this particular regard at the time of the release of the obstruction.

Vidgoff[2] states that in 266 cases of obstruction leukopenia was the "rule" because of the marked toxemia. However, his average count was 7,900 with 79 per cent polymorphonuclears, coursing as high as 28,000 in some instances. These counts were all preoperative. Russel[3] believes that blood studies reveal leukopenias in this condition, but this is given as a diagnostic aid only without subsequent leukocyte counts being made. Watson and Sargeant[4] discuss a well known fact, the low leukocyte count in pyogenic infections, appendicitis being one, and offer the possibility of the marked sepsis as the cause of the depletion of the white cells through repeated call of cells to the infected focus at a rate faster than their production by the bone marrow, a fact indicative of a very poor prognosis.

Cornell[5] in a series of 235 cases at the New York Hospital found the average

white cell count to be 15,445 with 80 per cent polymorphonuclear forms in intestinal obstruction. These counts also were preoperative counts. Rentschler[6] claims that in 100 cases cited, a normal leukocytic picture is seen depending upon the extent of the dehydration secondary to the vomiting. Of the series of Workman and Miller,[7] the white cells averaged 11,388 in thirty cases of simple obstruction and 12,886 in twenty-eight cases of obstruction with strangulation. In the Cook County Hospital compilation of Fey and Cubbins,[8] all of the 241 cases demonstrated a definite leukocytosis ranging from 10,000 to 20,000. However, in all the above quoted reports the counts appear to be preoperative counts.

We are presenting a series of ten cases of small bowel obstruction in which daily white blood counts were made following operation and in all of which was noted a marked leukopenia in the immediate postoperative period of from one to seven days. This leukopenia was not associated with surgical sepsis nor did it indicate necessarily a fatal prognosis as six out of these ten patients recovered. Although these ten cases are selected from a total of 185 cases of intestinal obstruction encountered in an eight-year period, they represent the only cases in the total group in which daily white blood counts were done in the immediate postoperative period. We, therefore, believe that this leukopenia would be more often noted in any large series of cases of obstruction if daily postoperative hemograms were made.

The clinical pictures of all of these patients were well marked examples of mechanical bowel obstruction, usually of the small bowel. The initial leukocyte count in all except Case VII was not greatly removed from the accepted normal for this condition, ranging from 6,800 white blood cells per cubic millimeter to 14,400. From the first to the fifth postoperative days following the removal of the obstructive lesion, a decisive drop from the total leukocyte count was noted, the extreme

low of 1,950 white blood cells being seen in Case II. A similar decrease in the differential polymorphonuclear count to lower levels during the postoperative course of the disease was a common characteristic with a relative leukocytosis and a moderate neutrophilic shift to the left. That a severe myelotoxic reaction was absent is evidenced by the lack of appearance of immature cells such as myelocytes in the stained smears. A few brief summaries of characteristic cases will be presented. Table 1 shows the complete series.

TYPICAL CASE REPORTS

CASE III. A. R., a forty-five year old female, had an appendectomy eleven years prior to entry. A week before admission to the hospital she complained of intermittent pains in the right lower quadrant, eventually presenting a large irregular palpable mass in the lower abdomen which suggested an obstructed small bowel. Flat films showed a bowel obstruction with the obstruction apparently involving multiple loops of small bowel throughout the abdomen. The preoperative white count was not unusual, being 11,750. At operation a large amount of brown fluid escaped on incising the peritoneum and multiple loops of distended blue-black small bowel were found. There was a complete volvulus of the root of the mesentery of the ileum producing a 180 degree twist. At the point of fixation was a thick band extending from the right side of the mesentery to the ileocecal region, probably representing adhesions from the site of the previous appendectomy. A second band was seen on the left connecting the parietal peritoneum and the mesenteric surface of a loop of small bowel. The bands were severed, the volvulus untwisted and the raw surfaces on the small bowel peritonealized. The patient was returned to bed in good condition.

From the preoperative count of 11,750 with 72 per cent polymorphonuclear forms, 24 per cent lymphocytes and a filament-non-filament ratio of 86:14, the count dropped the day following surgery to 2,700 with a differential count of 26:63 and a filament-non-filament ratio of 25:75. The patient maintained a consistent low level between 2,500 and 4,000 until the sixth postoperative day when a return of 5,500 leukocytes with 50 per cent granulocytes,

40 per cent lymphocytes and 50 per cent filamented forms were noted. The leukocyte level remained fairly high for the duration of the remainder of the convalescence and she made an uneventful recovery being discharged on the twenty-fifth postoperative day.

Remarks. This case of severe intestinal obstruction involving the small bowel showed this unusual postoperative leukocyte exhaustion characterized by a marked drop in the leukocytes following correction of the volvulus and the release of all points of obstruction. During this period of time her clinical course was essentially uneventful and in no way alarming. Her recovery was complete.

CASE IV. W. M., a twenty-five year old male who had an appendectomy thirteen years previously, entered the hospital complaining of cramp-like abdominal pain, followed by nausea, vomiting, distention and diarrhea of just a few hours' duration. The pain soon localized itself in the right lower quadrant.

Examination of the abdomen showed slight distention and moderate tenderness throughout, with marked pain and tenderness in the right lower quadrant. Percussion note was tympanitic and the patient presented evidence of hypohydration. Temperature 37.5°, pulse 100, respirations 22. Leukocytes totaled 14,500 with 80 per cent polymorphonuclears.

At operation the residue of an old adhesive peritonitis was found. In the right lower quadrant a torsion of the small bowel was discovered and freed with some difficulty. An entero-enterostomy was done about the site of the torsion. The patient's course was complicated only by a transitory gastric dilatation, in the first three days, otherwise his convalescence was uneventful and he made a complete recovery.

On the first postoperative day there was a rise to 23,400 but by the fifth postoperative day the leukocyte count dropped to 5,000 and the following day was recorded at 4,800 with 63 per cent polymorphonuclears, showing a definite shift to the left to 7 filamented cells and 56 nonfilamented forms. On the eighth day after surgery the count had risen to 11,300 with a filament-non-filament tabulation of 26:37, and remained normal until discharge on the sixteenth postoperative day.

Remarks. This case showed an unusual drop of over 18,600 cells in the course of six days to a very low level of 4,800.

CASE VIII. R. S., a thirty-two year old female, had an appendectomy for subacute appendicitis six months prior to entry to the hospital. Three days before admission the patient noticed some lower abdominal pain, not severe at first, but eventually forcing bed rest; she became nauseated and the pain radiated to the left lower quadrant. On examination there was moderate distention noted over the entire abdomen, and extreme tenderness to pressure was elicited in the left lower quadrant with less tenderness about the old right lower quadrant healed incisional scar. Flat x-ray films showed a definite small bowel mechanical obstruction.

At operation 750 cc. of a clear fluid were removed from the peritoneal cavity. The small bowel was dilated and stair-stepped in position. There was a band found coursing between the ascending colon and terminal ileum, and attaching to the mesentery of the terminal ileum causing a constricting obstruction. Two other areas of the ileum were found adherent by adhesive bands to the ileocecal junction. These bands were severed and the patient returned to bed in good condition. Her postoperative course was uneventful; she made a very satisfactory convalescence but the hemograms were of unusual interest. On the first, second and third days after surgery the white count dropped to levels of 5,100 and 3,700; with characteristic changes in the filamented forms. On the fifth postoperative day a rise to 4,400 was noted and on the seventh day it was decided to give the patient 500 cc. of blood to see whether this could effect the hemogram. The patient, however, was doing well. Following the transfusion there was a definite rise in the leukocyte level to essentially normal levels as seen in Table 1.

Remarks. The patient exhibited a moderately advanced mechanical bowel obstruction. Although she had a satisfactory clinical course following the release of her obstruction, the hemogram showed the characteristics of leukopenia which we are describing.

CASE X. G. B., age twenty-four, entered Mount Zion Hospital on October 14, 1940. He gave a typical history of lower abdominal pain characteristic of an attack of acute ap-

TABLE I

Case No.	Sex	Age	Diagnosis	Postoperative Day	Leuko-cytes	Neutro-philes	Lympho-cytes	Fila-mented	Nonfila-mented	Results
I. R. S.	F	47	Intestinal obstruction; carcinoma of colon; postoperative adhesions.	Preoperative	8,500	79	16	..	..	Died
				Fourth	2,600	67	25			
				Fifth	7,600	72	21	15	57	
II. B. N...	F	37	Intestinal obstruction; ruptured ectopic pregnancy.	Preoperative	14,400	84	16	..	.	Died
				First	13,100	93	7			
				Third	1,950	65	32			
				Third	2,550	67	26			
				Fifth	4,300	44	45			
III. A. R	F	45	Intestinal obstruction; volvulus; adhesions	Preoperative	11,750	72	24	86	14	Recovered
				First	2,700	63	26	25	75	
				Second	3,625	66	30	14	86	
				Third	2,500	70	27	32	68	
				Fourth	2,750	70	20	43	57	
				Fifth	5,100	56	40	50	50	
				Sixth	8,900	79	18	46	54	
				Seventh to twenty-fifth	Over 12,500					
IV. W. M.	M	25	Intestinal obstruction; postoperative adhesions	Preoperative	14,500	82	18		.	Recovered
				First	23,400	85	7			
				Third	10,000	74	21			
				Fifth	5,000	63	24	11	52	
				Sixth	4,800	63	22	7	56	
				Seventh	7,500	65	20	16	48	
				Eighth	11,300	63	26	26	57	
				Ninth to sixteenth	Over 12,500					
V A G	F	32	Intestinal obstruction; internal hernia	Preoperative	10,000	79	15	70	30	Recovered
				First	12,200	65	33	50	50	
				Second	10,300	87	13	51	49	
				Third	5,850	56	39	26	74	
				Fourth	4,550	59	38	53	47	
				Fifth to thirtieth	Over 9,000					
VI L G	M	59	Intestinal obstruction; carcinoma of prostate	Preoperative	6,800	70	18		.	Died
				Second	3,300	38	56	5	95	
				Third	3,800	42	53	8	92	
				Fifth	4,280	53	24	8	92	
VII C T	M	70	Intestinal obstruction, fibrous band	Preoperative	3,400	85	15	30	70	Died
				First	4,000	70	26	60	40	
				Second	3,700	63	33	40	60	
				Third	4,525	62	33	40	60	
				Fourth	4,550	77	19	50	50	
				Fifth	8,900	76	20	45	31	
				Sixth	14,000	82	14	36	46	
				Seventh	8,500	79	17	59	41	
				Eighth	8,750	78	18	44	56	
				Ninth	8,950	75	21	46	54	
				Tenth	6,000	76	20	27	73	
				Eleventh	4,600	84	12	65	35	
				Twelfth	8,200	90	8	68	32	
				Thirteenth	8,200	82	14	58	42	
VIII R S	F	32	Intestinal obstruction, postoperative adhesions	Preoperative	11,800	65	34	69	31	Recovered
				First	5,100	76	20	36	64	
				Second	4,050	68	24	50	50	
				Third	3,700	66	29	30	70	
				Fifth	4,400	67	30	20	80	
				Seventh	7,150	68	30	56	44	
				Tenth	8,250	58	38	80	20	
IX. A H.	F	24	Intestinal obstruction; postoperative adhesions	Preoperative	2,600	54	46			Recovered
				First	5,900	50	49			
				Fourth	6,400	60	40			
				Twenty-first	4,100	40	47			
X. G B	M	23	Intestinal obstruction. appendiceal abscess	Preoperative	15,000	91	8	73	27	Recovered
				Second	6,600	86	14	57	43	
				Third	4,100	86	13	59	41	
				Fourth	3,800	75	24	66	34	
				Fifth	3,500	86	12	46	54	
				Sixth	5,100	80	16	60	40	
				Eighth	4,550	84	15	65	35	
				Ninth	4,800	88	10	57	43	
				Tenth	6,950	82	18	30	70	
				Eleventh	8,050	88	10	55	45	
				Thirty-first	21,000	73	6	39	61	
				Forty-first	7,500	60	36	67	33	

pendicitis of a weeks' duration. He had taken purgatives.

Examination on admission to the hospital showed a board-like rigidity of the abdomen, temperature, 103°F., leukocyte count 15,000, and 91 per cent polymorphonuclears. A preoperative diagnosis of a perforated appendix was made with probable abscess formation.

At operation there was found a completely perforated appendix which was enclosed in the omentum and contained a large abscess. There was a moderate amount of peritonitic reaction between the loops of the small bowel but the picture was more that of a local peritonitis, rather than that of a spreading peritonitis. The patient was returned to bed in good condition.

On the second day postoperatively, the white count dropped to 6,600 with 86 per cent polymorphonuclears but nothing was particularly thought of this count at the time as the patient generally was doing well. His abdomen was not distended and he was passing small amounts of gas. However, on the third postoperative day his white count was down to 4,100 with 86 per cent polymorphonuclears and it was thought advisable to order a flat plate of his abdomen. He was not nauseated, nor had he vomited. The flat plate showed a definite small bowel obstruction in the ileocecal region with multiple dilated loops of small bowel. A Miller-Abbot tube was passed on this patient and after eight days of treatment with the Miller-Abbot tube, a check-up x-ray showed complete disappearance of the small bowel obstruction. The blood count as seen from the chart showed a moderate leukopenia during this period of time and by the time the patient had recovered from evidence of his bowel obstruction on the eleventh day his blood count was up to an essentially normal white count. It is of interest to note that on the thirty-first day postoperatively, the patient developed a temperature and a leukocytosis when evidence was found of a cul-de-sac abscess which was incised and drained through the rectum.

Remarks. This case illustrates the possible diagnostic value of this leukocyte exhaustion picture. Its appearance on the third and fourth postoperative days with no other evidence of bowel obstruction nor any evidence of a spreading peritonitis, suggested the possibility that he might

have a partial small bowel obstruction so that flat plates of his abdomen were ordered which definitely showed a mechanical obstruction of his small bowel. Treatment with the Miller-Abbot tube relieved this completely. It is also of interest to note that his leukocytic exhaustion was not a permanent condition as the patient was able to develop a real leukocytosis when he developed the late complication of a cul-de-sac abscess.

The entire series of ten cases is shown in detail in Table 1, the details of the monocyte, eosinophiles and basophilic tabulation have been omitted as there was nothing of unusual note detected.

DISCUSSION

That a definite lethal toxin is produced in a loop of obstructed small bowel is today a generally accepted fact. It is our belief that the preoperative distention of the obstructed loops compress the capillary circulation so that absorption from the obstructed loops of the toxin is minimal. The operative release of the obstructed loops apparently permits of drainage into better functioning loops of bowel and more rapid systemic absorption in the immediate postoperative period. This thesis would explain the leukocytic exhaustion seen in the postoperative period. An occasional case in which the leukopenia is noted preoperatively can be explained on the basis of an incomplete obstruction allowing some drainage from the partially obstructed loops into the nonobstructed loops, thereby permitting a certain amount of absorption of this toxin which has a depressing effect on the bone marrow.

We believe that the production of leukopenia as has herein been noted is part of the reaction of the patient to the sudden release of the toxic products. Peculiarly a definite paralysis of the bone marrow ensues so that the normal leukocytes are prevented from entering the peripheral circulation simply by repression of leukopoiesis. That a marrow reaction of this type is encountered is evidenced

not only by the leukocytic drop but also by a shift to the left in the filament-non-filament ratio. That the myeloid response is not too severe is demonstrated by there being no outpouring of any myelocytes or other immature forms in the primitive leukocytic series.

The paresis of the bone marrow by this or these toxins of intestinal obstruction following their release systemically may be moderately severe, however, as shown by the low point of the leukopenia, to wit, 1,950 white blood cells on the third post-operative day in Case II. Yet the severity of the reaction is not necessarily indicative of a fatal prognosis. The fact that this change in the hemogram appears immediately postoperatively and persists for a few days does not infer that a fatality will result, as a majority of the patients survived. Furthermore, they survived without coursing through a stormy postoperative period. These patients were not acutely ill, and at no time demonstrated any additional morbidity over the usual accompaniments of the disease when corrected surgically. The four deaths in the series resulted from the primary lesion in each specific case and not from the "leukocyte exhaustion."

The phrase, "leukocyte exhaustion," has been aptly applied by Van Duyn[9] to that state of the white cells existing in a progressive down-hill course following operation. Van Duyn found a leukopenia associated with a normal differential count and a marked shift to the left of the neutrophiles. This type of hemogram is indicative, he believes, of a marked strain on the leukopoietic powers of the patient, and in some instances where a leukopenic state exists prior to surgery, that it infers a "low leukocyte reserve."

Such a point was noted in Case VI, where preoperatively the patient presented a total leukocyte count of 3,400 with 85 per cent polymorphonuclears and a filament-non-filament ratio of 30:70. It is difficult to imagine a change in the patient's myeloid status in the short period prior to

the onset of this condition, sufficient to cause such a diminution of leukocytes. It is believed, preferably, that a partial obstruction must exist, without complete occlusion, permitting partial absorption of the toxin of obstruction into the general circulation, producing a lowered leukocyte level prior to a total release of the intestinal block by surgical means.

The demands made on the bone marrow at this time of need are great, and this is evidenced by the marked proliferation of young forms or nonfilamented polymorphonuclears seen in the shift to the left of that count. The toxic reaction of the marrow is not sufficiently severe as to cause the delivery of damaged leukocytes with unusual morphology. All the leukocytes seen were normal forms but few in number. Van Duyn did note this "leukopoietic breakdown" in two cases in which paralytic type of abdominal distention was present.

The present series of cases presenting leukopenia were not complicated by severe state of sepsis such as those cases described by Van Duyn and other writers in which the leukopenia indicate usually a fatal prognosis. In this series the postoperative course appears to be uninfluenced by the changes in the blood count and the majority of patients recovered without any clinical evidence of severe toxemia. No attempt was made in the present series to influence by some form of specific therapy the leukocyte count.

Therapy of such a condition as postoperative leukopenia has been attempted, particularly by Richmond,[10] who discussed a patient with an apparently normal leukocyte reserve who in the course of an abdominal infection developed a severe leukopenia with an associated drop in the granulocytes. As myelopoiesis is stimulated by the nucleotides, replacement therapy was attempted by Richmond in this case in which the normal stimulus had been damaged. A substance prepared by hydrolysis of yeast nuclei, called adenine sulfate, was given and effected myeloblastic activity favorably.

One questions the need of any specific therapy in view of the short duration of the lowered granulocytic state and the eventual excellent recovery in most of the cases. No specific therapy seems indicated as the leukopenia is only a symptom. The toxin of intestinal obstruction must be treated rather than the leukopenia.

The status of the leukocyte picture in intestinal obstruction can be determined very easily and any change in the white cell reserve anticipated through frequent and careful blood determinations done throughout the course of the disease. Daily counts of the total number of white cells and the making of differential smears are urged in order to establish the etiology of any unusual event in the patient's postoperative course in the treatment of intestinal obstruction. By so doing, it is hoped that some light may be shed on the nature of the toxin or substance responsible for the toxemia of bowel obstruction. The exact status of the myelotoxic reaction or myeloid hypoplasia was not known in our cases but could probably easily be determined by bone marrow biopsies. It is our hope that in the future an opportunity will present itself to perform some bone marrow biopsies on these postoperative intestinal obstruction cases.

SUMMARY

1. The occurrence of leukopenia in the immediate postoperative period following the release of intestinal obstruction and unrelated to any surgical sepsis is reported for the first time.

2. This leukopenia does not necessarily indicate a fatal prognosis or a severe postoperative course.

3. The mechanism of such a leukopenia is explained on the basis of the systemic absorption of the toxin of intestinal obstruction producing a temporary bone marrow paresis.

4. It is believed such a leukopenia is not a rarity and will be found frequently if routine blood counts are taken daily in the immediate postoperative period of cases of operative intestinal obstruction.

5. The presence of leukopenia of this type may occasionally give diagnostic value in early incomplete small bowel obstruction.

6. Treatment should be directed at the elimination of the toxin of intestinal obstruction rather than specific therapy to raise the leukocytic level.

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MALIGNANT ARGENTAFFINE TUMORS OF THE APPENDIX*

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ARGENTAFFINE tumors of the gastrointestinal tract are becoming of increasing interest because of the number that are found to be malignant. While malignancy among argentaffine tumors of the appendix is extremely rare, it does occur, and every argentaffine tumor is potentially malignant.

Merling[1] (1838) is generally supposed to be the first to describe a tumor of the appendix; Sellinger,[2] however, is of the opinion that a true tumor of this organ was not described until 1882 when Berger reported his case.

All tumors of the appendix prior to 1907 were called carcinomas. In that year Oberndorfer[3] described a group of tumors peculiar to the gastrointestinal tract and most common in the appendix. He concluded that these tumors were always benign, were slow of growth and were harmless. Oberndorfer called these tumors "carcinoids" because of their histologic resemblance to carcinomas. He stated that these "carcinoid" tumors are located in the submucosa, may invade the mucosa, but the muscularis and mucosa are always intact. He was the first to note the chromaffin nature of the tumor cells but did not establish the origin of the parent cells.

Several theories of origin of the tumor cells were advanced. Bunting[4] considered them analogous to Krompecher's basal cell carcinoma of the skin. Trappe[5] believed the so-called "carcinoids" and adenomyomas of the bowel arose from pancreatic rests which are fairly common in the gastrointestinal tract. Tonniessen[6] was of the opinion that they originated from epithelial rests in the gastrointestinal tract.

In 1897, Kultschitzky[7] described a peculiar cell in the mucosa of the gastrointestinal tract. This cell was most common in the appendix and was of decreasing frequency as the distance from the appendix increased. It was extremely rare in the colon. Schmidt[8] (1905) observed the chromaffin characteristics of certain cells of the bowel mucosa and suggested the possibility of these being the same type of cells described by Kultschitzky. Huebschmann[9] (1910) advanced the theory that these chromaffin cells gave rise to the "carcinoid" tumor of the gastrointestinal tract. It remained for Gosset and Masson[10] to demonstrate the silver staining granules in these tumor cells, whence the name "argentaffine" or "chromargentaffine" tumors. Lewis and Geschieter[11] classified these tumors as paragangliomas, supporting the work of Masson.[12]

As to the frequency of the argentaffine tumors of the appendix, Elting,[1] in 1903, could find only twenty three cases. Jackson[13] collected 317 cases from the literature up to 1923, which number was increased to 322 cases by 1934. To date over 400 cases have been reported. It is probably true that many more cases are not reported than reported, since 0.2 to 0.5 per cent of all appendices removed at operation contain argentaffine tumors.

CLINICAL FINDINGS

Argentaffine tumors of the gastrointestinal tract as a rule do not produce symptoms unless obstruction of the bowel lumen occurs. A few have metastasized to the regional mesenteric lymph-nodes and liver, giving symptoms characteristic of other malignancies of the gastrointestinal tract. On the other hand argentaffine tumors of the appendix are frequently discovered earlier not because of any characteristic

symptoms but because of symptoms referable to the appendix. The symptoms are usually those attributed to so-called chronic

bright yellow. Sometimes there are multiple tumors.

On rare occasions the tumor metasta-
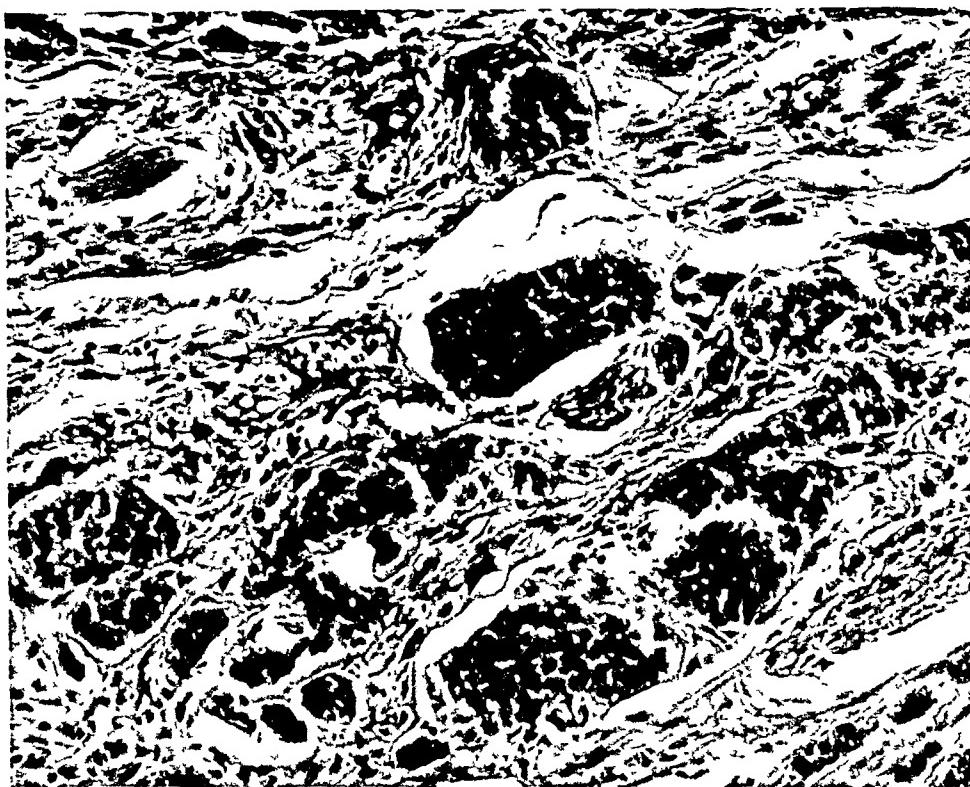
Fig. 1. Photomicrograph of Case 1 showing large groups of tumor cells in the muscle layer of the appendix extending to the serosa.

appendicitis, the most frequent symptom being dull pain in the right lower abdominal quadrant. The symptoms may be more acute with sharp pain, nausea and vomiting—the neurogenic appendix of Masson.[14] Acute appendicitis may be superimposed giving rise to symptoms of acute inflammatory process.

GROSS PATHOLOGY

Argentaffine tumors of the appendix are usually located in the distal third of the organ. It is a nodule in the submucosa. While the lumen appears to be obliterated, the mucosa, in reality, is lifted up and is pressed against the mucosa of the opposite wall. The lesion averages from 0.5 to 1.0 cm. in diameter but in rare instances is large enough to be palpated through the intact abdominal wall. The serosa of the appendix is, as a rule, normal. The tumor may be yellow in color and its cut surface is

sizes into the regional lymph-nodes, and distant metastasis may occur in the liver. The tumor may invade the mesoappendix by direct extension. Bailey[15] states that the metastases occur characteristically outside the lymph-nodes and smaller groups of actively proliferating cells invade the nodes. Raiford[16] believes the metastatic cells enter the lymph-nodes by way of the lymphatics causing a profuse fibrosis which destroys and replaces the lymphoid tissue.

MICROSCOPIC PATHOLOGY

Raiford[16] has given an excellent description of the microscopic anatomy of the argentaffine tumors. The tumor cell nests are usually separated by dense connective tissue but may be packed closely together. A false capsule is formed by the smooth muscle fibers of the bowel wall. These muscle fibers are frequently invaded by tumor cells. The cells have distinct nuclei but the

cytoplasm is indistinct. Smaller cell groups may be arranged in rosettes. The cells are columnar in shape, have distinct cell

The difficulty in determining the incidence of malignant lesions is due in part to the hesitancy of some pathologists to call

FIG. 2. Photomicrograph of Case 11 showing large tumor masses in the muscle wall. Note the difference in staining quality of the tumor cells in certain groups.

borders and resemble neuroblastomas. The cells contain silver staining granules which are easily demonstrated by proper staining technic. Bailey[15] found elastic tissue in great abundance in these tumors, whether benign or malignant. Mitotic figures while present are not abundant. The histologic picture is characteristic but if doubt exists silver stains will confirm the diagnosis.

MALIGNANCY

While metastases are not the rule they do occur. The tumor may invade adjacent tissues by direct extension. Lewis and Geschicter[11] state that 20 per cent of the argentaffine tumors become malignant. Malignancy of argentaffine tumors of the appendix is less frequent.

an argentaffine tumor malignant unless the regional lymph-nodes or the liver are invaded. Some authors do not classify argentaffine tumors malignant when they have invaded the mesoappendix but have not extended to the regional lymph-nodes. Raiford[16] considers the degree of malignancy to increase as the distance of the lesion from the appendix increases.

That argentaffine tumors of the appendix are less often malignant than similar lesions located elsewhere in the gastro-intestinal tract is due to the earlier removal because of positive symptoms necessitating surgical intervention. Bailey[15] collected seven cases of malignancy of argentaffine tumors of the appendix from the literature. He considered malignant a similar lesion of

the ileum that had extended into the adjacent mesentery, while Forbus[17] did not consider as malignant two tumors of the

the ileum because of an argentaffine tumor. He died fifteen years later of an entirely unrelated condition. At the postmortem
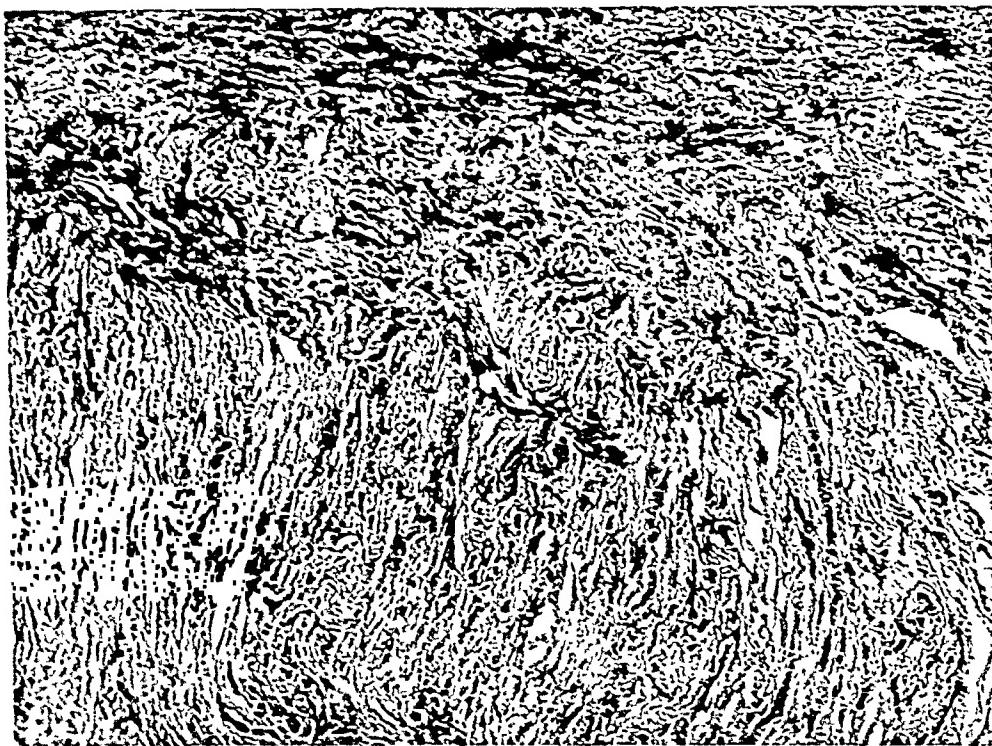
Fig. 3. Photomicrograph of Case III showing the muscle wall of the appendix invaded by tumor cells. Note the cord-like arrangement of the cells in the lower half of the picture.

appendix that had extended into the mesentery. The total number of malignant carcinoids of the appendix reported in the literature is fourteen.[18,19] Three new cases are added in the present report. The total number of malignant argentaffinomas of the entire gastrointestinal tract and gallbladder reported amounts to seventy-three.

It is generally agreed that all argentaffine tumors are potentially malignant. However, most of them are of low grade malignancy and require a long time to metastasize. They will break through the bowel structure and infiltrate the adjacent mesentery or may become implanted as "kissing" metastases. From this local invasion the tumor cells may metastasize to the lymph-nodes or beyond.

Even the metastatic cells may be of a very slow and relatively benign type as illustrated by a case reported by Mallory[20] from the Massachusetts General Hospital. The patient had a resection of a portion of

examination a retroperitoneal lymph-node was found that contained argentaffine tumor cells. The metastasis had occurred at least fifteen years before death but had not spread beyond that single retroperitoneal lymph-node.

The author has recently removed two argentaffine tumors of the appendix which he considered malignant. One extended into the adjacent mesoappendix, the other was attached to the brim of the pelvis where the appendix was lying adjacent to this structure. A third case is briefly reported here. This latter case is to be reported in detail later.[21]

CASE REPORTS

CASE I. A white male, thirty-eight years of age, presented himself on July 31, 1938, because of acute colicky abdominal pains of seventeen hours' duration. The history was suggestive of acute appendicitis but there was no nausea, vomiting or change of bowel habit.

The patient was well developed and well nourished. His temperature by mouth was 100.6°F. There was tenderness on pressure and slight protective rigidity in the right lower quadrant of the abdomen. Marked rebound tenderness was present in this area. Rovsing's sign was positive. The erythrocyte count was 5,170,000, hemoglobin 16.7 Gm. (99 per cent Newcomer). The white blood count was 11,600 with 86 per cent polymorphonuclear neutrophils. An acutely inflamed appendix was removed through a muscle splitting incision.

The pathologist's macroscopic report was as follows: The appendix measured 8 by 3/4 to 1 1/4 cm. The serosa was dull and hyperemic in the distal half. The distal one-fourth of the appendix was markedly distended. In this portion of the lumen there was a very hard fecalith. Distal to the fecalith the wall of the appendix was very thick and edematous. Portions of this wall appeared to be necrotic.

Microscopically, the portion of the appendix wall which appeared to be thickened by fibrosis was infiltrated by tumor tissue. Within the lumen of the appendix were groups of rounded or oval cells which were not very large or chromatic. These groups of cells were separated by narrow strands of connective tissue. The individual cells were uniform in size and mitotic figures were quite rare. There was a gradual transition from the above described cells to cells of the same size but which were more chromatic, growing in narrow spindle-shaped groups, invading the muscle wall and the mesoappendix. Mitotic figures were more numerous among these cells. There was necrosis of the appendiceal mucosa adjacent to the tumor tissue and the lumen was filled with necrotic tissue and pus cells. At one point there was necrosis of the tumor tissue.

Diagnosis: Acute appendicitis superimposed on a malignant argentaffine tumor of the appendix.

This patient is still well after removal of the lesion. Frequent examinations have not revealed any evidence of recurrence, even though it was not certain that all of the tumor tissue was removed from the mesoappendix.

CASE II. An apathetic white male, twenty-one years of age, was admitted to the Wesley Memorial Hospital May 22, 1939. His complaints were nausea and fullness in the epigastrium after meals for a duration of two years. For the past four years he had had repeated attacks of acute abdominal pains with fever, nausea and vomiting that had been diagnosed by his family physician as acute appendicitis. The last such attack was five weeks previous to admission to the hospital. Several gastrointestinal studies had failed to reveal any abdominal pathological condition. Because of self-imposed dietary regulations, the patient had lost over forty pounds. The blood and urine findings were within normal limits.

At the time of the operation the stomach and duodenum were found normal. The gallbladder was covered with omentum which was lightly attached by fibrous adhesions. The gallbladder wall was thin and blue and the gallbladder was easily emptied by pressure. The appendix was normal in the proximal two-thirds but the distal third was enlarged, thickened and firmly attached to the brim of the pelvis by granulation tissue and fibrous tissue. The appendix was freed with difficulty and removed. There were no enlarged regional lymph-nodes either in the mesoappendix or mesentery of the terminal ileum.

The pathological report was as follows: The appendix was 7 by 0.75 cm. The wall was fairly uniform in thickness except in the distal 1 cm. The tip was thickened and sections made by cutting were slightly yellow in color.

Microscopically, sections through the thickened distal portion of the appendix showed replacement of most of the submucosa by groups of tumor cells. The tumor cells were fairly uniform in size and shape and were not very chromatic although the cells contained more than the usual amount of chromatin that is found in the strictly benign carcinoid. The groups of cells varied much in size and could be found in all layers of the wall including the serosa. Hyperemic granulation tissue was present about the groups of tumor cells and a moderate small round cell infiltration was present in all layers of the wall of the distal portion of the appendix. A few mitotic figures were present. The mesoappendix did not contain tumor cells. The invasion of the wall with scattered small groups of cells which were slightly more chromatic than normal for carcinoids strongly suggested malignancy.

Diagnosis: Malignant argentaffine tumor of the vermiform appendix.

Discussion of Case II. Since the serosa was invaded by tumor cells at a point

corresponding to the attachment of the tip of the appendix to the pelvic brim, one must conclude that tumor cells were implanted in the peritoneum at this point of attachment.

One year after operation a thorough gastrointestinal examination failed to demonstrate any lesion of the bowel. As a prophylactic measure high voltage deep x-ray therapy has been used on this patient.

CASE III. This patient was operated upon by Doctor R. N. Bills and the specimen was examined by Doctor E. R. Strauser, of the Wesley Memorial Hospital and is reported here through their courtesy. A white woman (Mrs. F. B.), sixty-three years of age, was admitted to the Methodist Hospital, Gary, Indiana, because of acute symptoms referable to the right lower abdominal quadrant. There was marked tenderness and rebound tenderness over McBurney's point. The erythrocyte count was 5,230,000, hemoglobin 13.4 Gm. (92 per cent), white blood count 20,300 with 90 per cent polymorphnuclear leukocytes. At operation, November 3, 1939, a fibrotic appendix was removed.

The gross pathology revealed the appendix to be 6 by ¾ to ¼ cm. with an irregularly thickened wall. The wall was fibrotic, especially the distal portion. The distal portion of the lumen was obliterated.

Microscopically, the lumen of the distal portion of the appendix was completely obliterated by tumor growth which was composed of small alveolar and tubular units. There were no sharp cytoplasmic limits of the tumor cells but apparently the cells were of the low columnar or cuboidal type. Only a few of the tubular or alveolar structures had lumen. This may be due to the fact that they were filled with material with staining properties similar to the cytoplasm. The tumor cells were only moderately chromatic but some had distinct nucleoli and there were a few mitotic figures. Extending through the muscle wall and serosa were small spindle-shaped groups of deeply stained cells which tended to split muscle bundles and in places were associated with the same type of cell as those in the lumen. This growth in the muscle wall and serosa had very much the appearance of a scirrhous carcinoma with the muscle tissue taking the place of fibrous stroma. Only a small segment of muscle wall was with-

out this tumor tissue. Tumor cells had invaded the mesoappendix.

Diagnosis: Malignant argentaffine tumor of the appendix.

MANAGEMENT OF ARGENTAFFINE TUMORS

Whether benign or malignant, argentaffine tumors should be surgically excised. These tumors when located in the stomach or bowel should be excised along with adjacent bowel and mesentery. If metastases to regional lymph-nodes are present, these should be removed if possible.

Simple appendectomy will suffice in almost all cases of argentaffine tumors of this organ. In fact the diagnosis usually is not made until the microscopic examination is made. In cases in which a nodule is felt in the wall of the appendix, the organ should be cut through in this area; and if yellow tissue is present, the mesoappendix and mesentery of the terminal ileum should be closely searched for visible or palpable lymph-nodes. If any are found, they should be removed. Also if the diagnosis of argentaffine tumor is made during the course of an appendectomy, a liberal portion of the mesoappendix should be removed if possible.

Leaving an involved lymph-node is not necessarily fatal as illustrated by Mallory's case,[20] yet incomplete removal of malignant lesions or metastases may be responsible for recurrence.

CONCLUSIONS

1. Carcinoid or argentaffine tumors of the gastrointestinal tract originate from argentaffine cells described by Kultschitzky.[7] These cells are believed to be related to the chromaffin system.

2. Argentaffine tumors occur most often in the appendix but may occur in the stomach, small bowel, Meckel's diverticulum, colon and gallbladder.

3. Argentaffine tumors are present in 0.2 to 0.5 per cent of all appendices removed surgically.

4. While the lesion is most frequent in the appendix only seventeen of the seventy-

six malignant argentaffine tumors, including three cases here reported, occurred in the appendix.

5. Argentaffine tumors of the appendix are less frequently malignant because they produce clinical symptoms and are removed earlier than similar lesions elsewhere in the gastrointestinal tract. All argentaffine tumors are potentially malignant.

6. Three new cases of malignant argentaffine tumors of the appendix are reported.

7. Surgical removal is the treatment of choice of all argentaffine tumors.

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operable cases at Bellevue. Stated another way, a case admitted to Post-Graduate Hospital with a diagnosis of cancer of the stomach had one chance in four for resectability. If operable his chances were one in three.

TABLE III
OPERATIONS

Procedure	Number	Improved	Unimproved	Died
Exploratory	53		43	10
Palliative	48	27		21
Resection	50	28		22
Total	151	55	43	53

The mortality in our resectable cases was 44 per cent, at Bellevue it was 54.2 per cent.

TABLE IV
RESULTS OF PALLIATIVE OPERATIONS

Procedure	Number	Improved	Died
Gastrostomy	5	2	3
Jejunostomy	5	4	1
Gastroenterostomy	38	21	17
Total	48	27	21

Palliative operations are listed in Table IV. All those who survived their operation and left the hospital were classed as improved, though one might well question the meaning of the word "improved" in gastric cancer which is found to be resectable.

DIAGNOSIS

Age and Sex. There were 145 males and fifty-seven females, a ratio of about three to one; the majority occurred between the ages of forty-one and seventy. There were twenty-nine cases between the ages of twenty and forty years.

Symptomatology. While pain, weight loss, nausea and vomiting were most commonly presenting symptoms, they differed somewhat from those at Bellevue. In the latter series, nausea and vomiting were not as common, while other more advanced signs such as weakness, cachexia and jaundice were found much more frequently. Anorexia, considered usually as a common early symptom, was a complaint in 31.7 per cent of our cases. What constituted the true early symptoms and found uniformly predating the tabulated findings, were increasing heartburn, epigastric "distress," eructations, and other similar vague complaints. A mass considered often a hopeless sign, was felt in forty-three cases. (Table v.)

TABLE V
PRESENTING SYMPTOMS AND SIGNS IN ORDER OF FREQUENCY

Symptoms and Signs	Number	Percentage
Pain	155	76.2
Loss of weight	145	71.8
Nausea or vomiting	121	59.9
Anorexia	64	31.7
Weakness	55	27.2
Cachexia	45	22.3
Mass	43	21.3
Jaundice	7	3.5
Hematemesis	7	3.5

Duration of Symptoms. There was no direct relationship between duration of complaints and operability or resectability. There was a higher percentage of resectable cases in the group having symptoms for six months to three years than the group having symptoms for one to six months. (Table VI.) This finding was also present in the Bellevue series and is probably related to type and grade of gastric cancer.

Relation to Peptic Ulcer. In our series there were twelve cases in which co-existing ulcer and tumor were diagnosed by x-ray, while eight cases gave a past history of perforation, hemorrhage, or previous roentgenological diagnosis of ulcer. What is more interesting was an unqualified pathological diagnosis in five cases of "carcinoma following ulcer." The latter condition has been discussed by many

others[2,1] and its authenticity is at best, difficult to prove.

Duration	Number	Non-operable	Operable	Resection
Less than 1 month..	11	4	5	2
1 to 3 months........	33	4	22	7
3 to 6 months.......	48	17	24	7
6 to 12 months......	48	11	25	12
1 to 2 years.........	24	5	9	10
2 to 3 years........	12	2	5	5
3 to 5 years........	6	1	2	3
5 to 10 years.......	5	..	4	1
Over 10 years.......	3	..	1	2
Unknown.....	6	1	4	1
Total...........	196	45	101	50

X-ray Diagnosis. A gastrointestinal series was performed in 122 cases. It is to the credit of our x-ray department that in 116 of these cases a correct diagnosis of neoplasm was made. Three cases were diagnosed as "ulcer," two others as "extra gastric tumors," and one was reported "negative." Following laparotomy these six cases proved to be gastric cancer. Forty-nine of the cases were located in the pylorus while thirty-six were so extensive as to be listed under "multiple sites," meaning more than one anatomical subdivision of the stomach. (Table VII.)

Site	Number
Esophagus.... 2	
Cardia...... 4	
Fundus.... . ... —	6
Lesser curvature..... 8	
Media................................. 10	
Greater curvature .... 1 —	19
Pylorus.............. 40	
Proximal half........................ 1	
Distal half............................ .. 2	
Entire stomach........................ 3 —	6
Multiple sites..	36
	116

Gastric Analysis. Forty-four cases were tested for free hydrochloric and total acid and six others for free hydrochloric acid only. There were eighteen cases with normal or high free hydrochloric acid of which two had an associated ulcer. (Table VIII.)

	None	Low	N	High	Total
Free hydrochloric acid............	30	2	9	9	50
Total acid........	..	21	15	8	44
Blood............	..	..	..	.	23

DISCUSSION

The comparison proved interesting in that it bore out your original impression that selectivity played a great part in determining the outlook in gastric cancer patients. At the Post-Graduate Hospital, where the economic level of clinic patients is definitely higher than that of Bellevue patients, there was already a marked increase in the number of operable and resectable cases. And with the improvement in present day preoperative and postoperative care as well as operative technic, the prognosis should improve. A real problem is that of early diagnosis, and x-ray examinations and gastroscopy are essential for what one might call "the prodomal symptoms," such as increasing heartburn or epigastric distress in an adult regardless of age if the early diagnosis is to be made. With a diagnosis of gastric cancer, surgery, if at all possible, should be performed. The patient with a mass in the abdomen clinically, or an extensive lesion roentgengraphically, may prove to be much easier to resect than the one with a small lesion at the cardia. Striking an optimistic note in gastric malignancy are occasional reports of long standing cures following surgery. The ten- and fifteen-year cures following subtotal resections should be reviewed by a group of pathologists in

order to remove any question of doubt as to the diagnosis in view of the generally poor results from a follow-up of gastric carcinoma.

CONCLUSIONS

1. Operability and resectability in gastric cancer are greatly influenced by selection of cases. Comparison of Bellevue with New York Post-Graduate cases illustrates this well.

2. Operability and resectability in gastric cancer are not directly related to duration of symptoms. At Bellevue and New York Post-Graduate Hospitals there was a higher percentage of resectable cases in the group having symptoms for six months to three years than in the group having symptoms for one to six months.

3. Careful x-ray examination and gastroscopy are the most dependable means of diagnosis at the present time.

4. Surgery offers the only hope of cure in gastric cancer. That the patient with a short history has no better chance of a cure than the one with a long history presents a real enigma. Increased knowledge of causative factors, type and grade of cancer may solve this problem. Meanwhile, progress must remain in the direction of bringing more patients to surgery whenever possible.

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A METHOD TO PREVENT FRESH COSTAL CARTILAGE GRAFTS FROM WARPING*

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AN innate quality of freshly removed costal cartilage is its tendency to undergo distortion by warping. From the viewpoint of plastic surgery, this attribute is most objectionable. When fresh costal cartilage is employed as an implant to correct a facial defect such as a receding chin, a saddle-back deformity of the nose, or a flattened cheek of traumatic origin, it is most disconcerting and not unusual to discover postoperatively that the graft has curled to such an extent as to interfere with the desired cosmetic result. It is regrettable that this tissue, which lends itself so perfectly to both autogenous and homogenous transplantation, which withstands infection so satisfactorily, and which may be cut to any desired contour with ease and accuracy, should possess the undesirable tendency to warp.

However, a method has been evolved by which the physical nature of fresh cartilage may be rapidly altered; thereafter, unless the cartilage has been obtained from a very young person and has been cut to a feather edge, any inclination to bend which it might have possessed will no longer exist. The surgeon may then proceed to cut and shape the cartilage with no fear of the occurrence of subsequent distortion.

Of inestimable value is the discovery made in recent years that cartilage can be transplanted successfully from one individual to another, and that it may be preserved for an indefinite period in aqueous antiseptic solutions maintained at icebox temperatures. These facts, as applied to plastic surgical procedures, permit utilization of cartilage obtained under sterile conditions at necropsy. As is well known, preserved cartilage when cut retains its shape because it has undergone a spontaneous process of fixation which has destroyed its elasticity. Although it is true that we have employed implants obtained at necropsy with much success in a large series of cases, it always has been our opinion that the use of fresh, autogenous, cartilage grafts is preferable to the aforementioned procedure. Consequently, for several years we have sought some means by which fresh cartilage could be prevented from warping.

The one factor which effectually contributed to the end which we sought was a suggestion offered by Dr. J. W. Kernohan of the Sections on Surgical Pathology and Pathologic Anatomy. Since steaming quickly produces fixation of small bits of tissue to be subjected to microscopic examination, Dr. Kernohan proposed that the process of boiling might accomplish with rapidity the desired fixation of costal cartilage, and might thereby avert the tendency of such cartilage to undergo subsequent distortion. Although the results of the experimentation which was prompted by this suggestion differed from our expectations, they constituted a foundation for the method which we now employ and which, without exception, we have found to be completely satisfactory.

Although boiling does bring about fixation of fresh cartilage, it also produces multiple ruptures in the cartilaginous matrix; this action causes deep external cracks and induces an extreme degree of curling which frequently renders the tissue useless as an implant. It was found later, however, that the undesirable effects of boiling could be entirely avoided if the

solution in which the cartilage was immersed never was permitted to reach the boiling point. The procedure can be carried

FIG. 1. A piece of fresh costal cartilage being heated to overcome its tendency to warp.

out most easily by placing the piece of cartilage in a test tube containing water or, preferably, aqueous sodium ethyl mercurithiosalicylate (merthiolate); the tube is then inserted upright in a beaker containing boiling water. Although in time the solution within the test tube will become hot, it will be physically impossible for it to boil if this method is followed. To be exact, the solution will remain 3 or 4°C. below the boiling point of water. Cartilage so heated will warp very little if at all, unless two or more pieces are introduced into the same tube; if this is done, the fragments tend to become moulded together and undergo more or less distortion. It has been discovered, further, that the cartilage which has been subjected to the aforementioned heating process will undergo on cooling a certain amount of warping. Consequently, it is of the utmost importance that heated cartilage be allowed to cool before it is cut to the desired shape. It is well to mention here that if the end of a cartilaginous implant is trimmed to a feather edge, a tendency for such an extremely thin margin

to curl slightly may be encountered, whether or not the cartilage previously has been heated. However, such curling
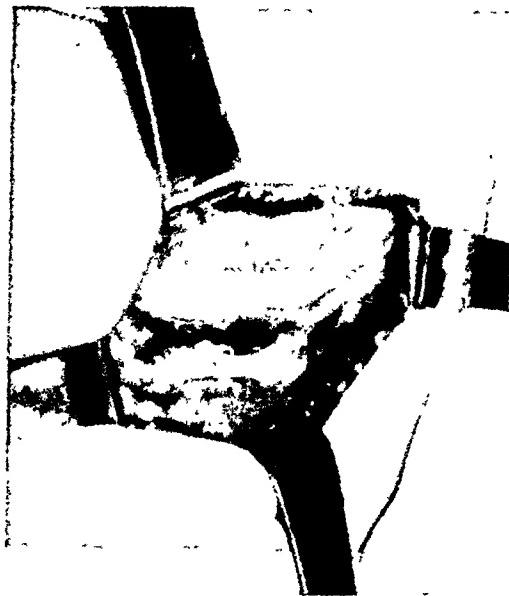
FIG. 2. The cartilaginous portion of the right seventh and eighth ribs is exposed through a transverse incision in the skin. Grafts may be prepared most easily from costal cartilage when the entire thickness of the rib is removed subperichondrially.

may be remedied easily by cutting away that portion of the fine edge which is bent.

As a result of the foregoing experimental work the following technic for heating and cooling cartilage has been evolved, the purpose of which is to nullify any inclination of a finished implant to warp. After a full-thickness section of cartilage has been obtained from one of the patient's ribs, the piece is introduced into a sterile test tube into which is poured sufficient solution of aqueous sodium ethyl mercurithiosalicylate (merthiolate) completely to cover the fragment of cartilage. The tube then is placed in a beaker of water which is allowed to boil for ten minutes. (Fig. 1.) Although not essential, it is advisable that the bottom of the beaker be covered with several layers of gauze. When the cartilage is removed from the test tube, it is immersed, as a final step, in cold sterile physiologic solution of sodium chloride for at least fifteen minutes.

In the performance of any plastic procedure in which a cartilage implant is used, the aforementioned technic for the preparation

for reception of the implant by the time the treated cartilage has been made available for cutting and proper shaping.

FIG. 3. a, Lateral preoperative view and b, postoperative view of a patient with nasal defect which was corrected by the use of a fresh autogenous implant of costal cartilage. Warping of the graft was obviated by heating and cooling the cartilage before it was cut to the desired shape.

FIG. 4. a, Frontal preoperative view and b, postoperative view of the patient in Figure 3.

tion of this tissue need neither consume additional time during the operation nor demand extra work on the part of the surgeon. After a section of cartilage has been obtained from a rib, the surgeon may proceed immediately to the preparation of the operative field of the facial defect, while a nurse heats and chills the cartilage and the assistant surgeon closes the incision in the thoracic wall. With few exceptions, the defect of the face can be fully prepared

Some surgeons have voiced objections to excision of costal cartilage for use in cosmetic operations, but we have encountered no complications or ill effects secondary to the removal of costal cartilage for such purposes. Naturally, the selection of ribs from which such cartilage is to be taken is of considerable importance. We never attempt to remove cartilage from the left side of the thoracic wall, and on the right side we prefer to obtain cartilage

from the seventh rib. An oblique incision in the skin extending from the center of the sternum just above the xyphoid process to the lower border of the thoracic cage in the region of the right midclavicular line will produce excellent exposure. When the attachments of the pectoralis major and the oblique and rectus abdominis muscles are severed, the cartilaginous portion of the right sixth and seventh ribs (which unite anteriorly with the sternum) and the cartilaginous part of the eighth rib (which joins the costal cartilage of the seventh rib) are effectively uncovered. (Fig. 2.) In the majority of instances, the cartilage of the seventh rib is least difficult to procure and it supplies an amount of material which is adequate for the average implant. We always take the full thickness of a rib, the section of which is removed subperichondrially. If a large graft is required, cartilage from the sixth rib may be used as well. A fine columella, which is essential to the correction of certain nasal deformities, can be constructed from the narrow cartilaginous portion of the eighth rib.

Incidentally, unused pieces of cartilage should not be discarded; instead, they may be preserved in an aqueous antiseptic solution in an icebox. This stored material is extremely valuable for use in individuals who have a large defect, such as loss of considerable bone in the frontal region, a circumstance in which the maximal amount of cartilage that could be obtained from the patient would be insufficient fully to correct the deformity.

In conclusion, we would like to reassert that in our experience none of the cartilage implants which have been treated by our method of heating and cooling, as has been described, have undergone the slightest amount of distortion postoperatively. It is our hope that those surgeons who employ fresh, autogenous, cartilage transplants in the correction of facial defects will find that this method affords the high degree of satisfaction which we have experienced, a satisfaction based on the assurance that the desired cosmetic result will not be altered by a failure of the implant to retain its proper contour. (Figs. 3 and 4.)

SURGICAL TECHNIC FOR REMOVAL OF SOLITARY
DESTRUCTIVE NEOPLASTIC LESIONS OF THE CRANIUM*

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SOLITARY destructive neoplastic lesions of the calvarium may present a problem both as to diagnosis and removal. The diagnosis is not considered here.

Roentgenograms were not conclusive in two of the four patients treated surgically. That examination of a specimen taken at biopsy is not always infallible was demonstrated in one patient in whom the tumor was believed to be an angioblastic meningioma, but after removal of the entire tumor *en masse* it was found to be metastatic, probably renal in origin. Since biopsy is not always correct and therefore does not settle the problem of removal of the local tumor, and since the latter is associated with various discomforts, it seems reasonable to advise complete extirpation by the method to be described. Granting, of course, that no primary growth elsewhere or other possible metastases can be found, roentgen treatment has been disappointing because the patients are very unhappy with most of their hair out, and in two of our patients roentgen treatment served only to show the protrusion more clearly, whereas previously it was covered with hair. It is a fallacy that blood supply is cut down sufficiently by roentgen treatment to make a difference in blood loss at the time of operation except in the scalp where a rich blood supply is desirable and should never cause technical difficulties.

The underlying principles of the technic are those used in the removal of meningiomas. However, in meningiomas only a small amount of bone has to be discarded and the tumor usually covers much more surface of the brain than the involved bone.

In the localized destructive lesions of the bone the tumor is no larger than the involved bone. In order to carry out complete extirpation, the technical steps must be followed carefully in sequence if the procedure is to be executed in an orderly and relatively simple manner.

A "U" shaped incision is made sufficiently large to allow 3 or 4 cm. of a normal edge of bone to be uncovered surrounding the tumor. (Fig. 1a.) The scalp is reflected, taking considerable care to stay in the line of cleavage between the galea and periosteum. (Fig. 1b.) The periosteum forms an excellent barrier since in none of the patients had the tumor grown through it even though tumor tissue had invaded it. If the periosteum is not allowed to remain undisturbed over the tumor, liquefied and necrotic portions escape and troublesome bleeding from the bone takes place. Also, tumor cells may be transplanted. After the scalp has been adequately reflected an incision is made through the periosteum well away from the tumor edge but completely encircling it. (Fig. 1b and c.) The periosteum is then stripped away from the normal bone toward the edge of the tumor. In this way enough normal bone is uncovered so that a trough about the width of the usual burr openings can be made surrounding the entire tumor mass. (Fig. 2a.) A strip of normal dura about 1 cm. in width will lie uncovered at the bottom of the trough. (Fig. 2a.) Bleeding from the bone edges must be controlled with wax. In a dry field the dura is incised, the medial edges are grasped with curved hemostats and gentle traction exerted. (Fig. 3a.) As the incision in the dura lengthens, the
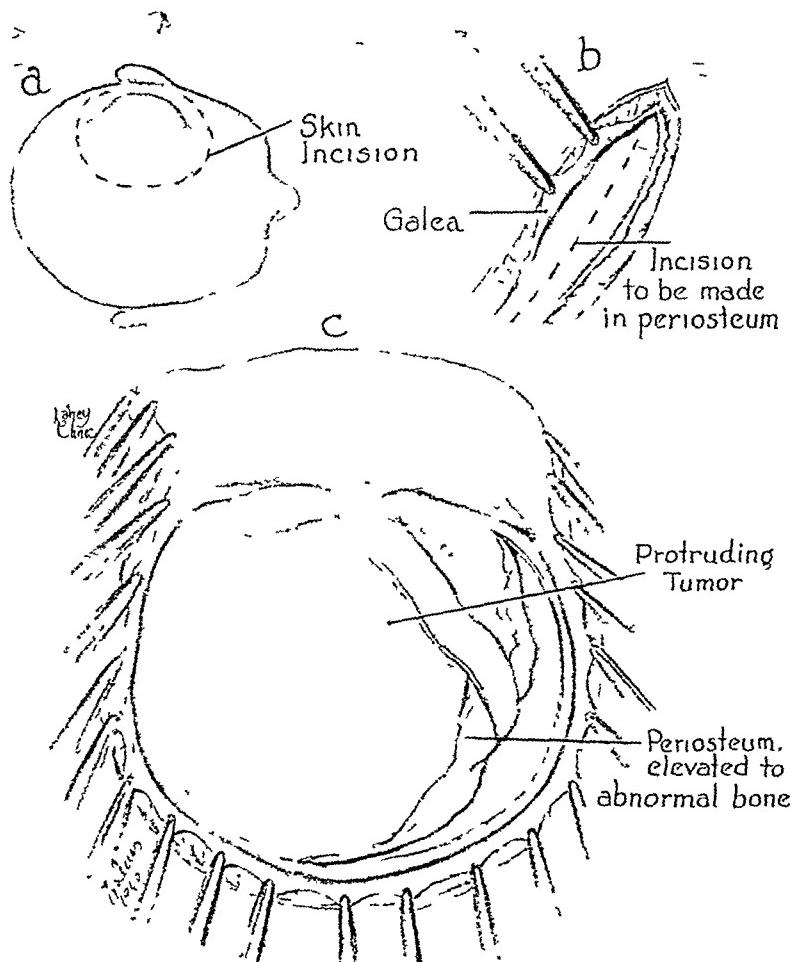
FIG. 1. *a*, Outline of incision showing generous margin around tumor-involved bone; *b*, demonstrates the line of cleavage which must be kept intact between periosteum and galea; *c*, scalp reflected leaving periosteum intact over tumor mass.
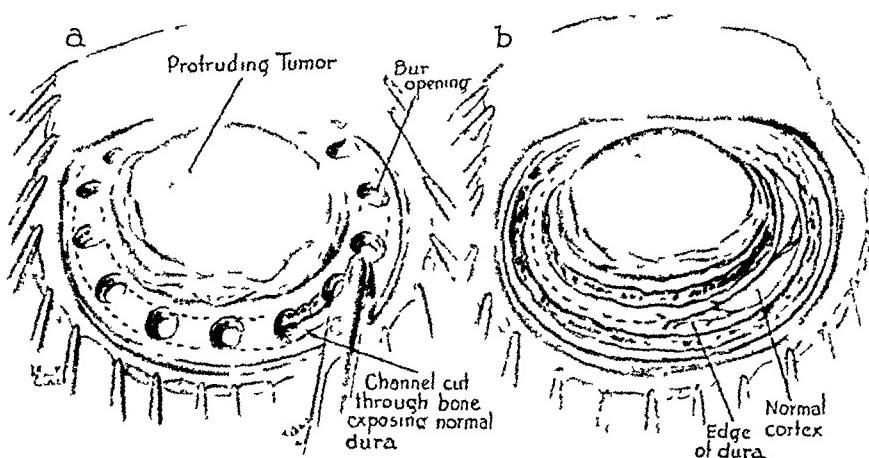
FIG 2. *a*, The periosteum is reflected up to tumor-involved bone and a channel cut through bone sufficiently wide to allow the dura to be incised as shown in *b b*, Dura incised showing flattened cortex but not involved with tumor
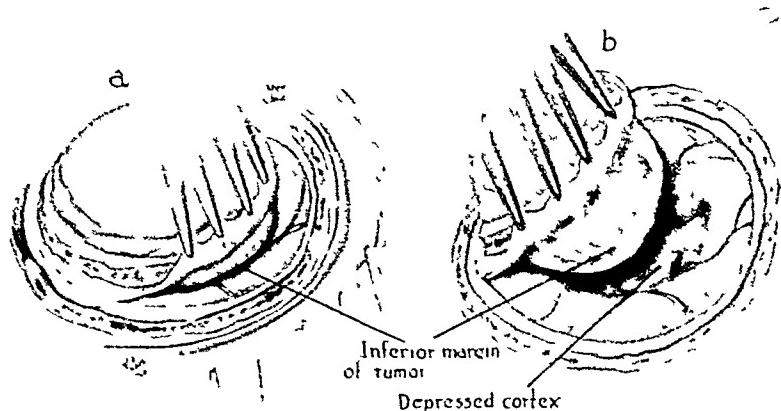
Fig. 3. a, the medial edge of the dura is grasped with hemostats and a gentle pull demonstrates the tumor edge which has depressed the cortex; b, elevation of tumor from its nest in the cortex.
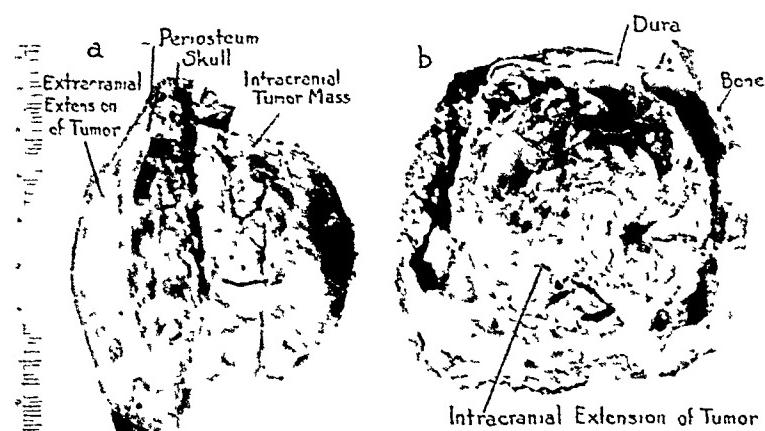
Fig. 4. Side view (a) and inferior surface (b) of meningioma removed en masse showing intracranial, cranial and extracranial extensions of tumor.

a   b   c
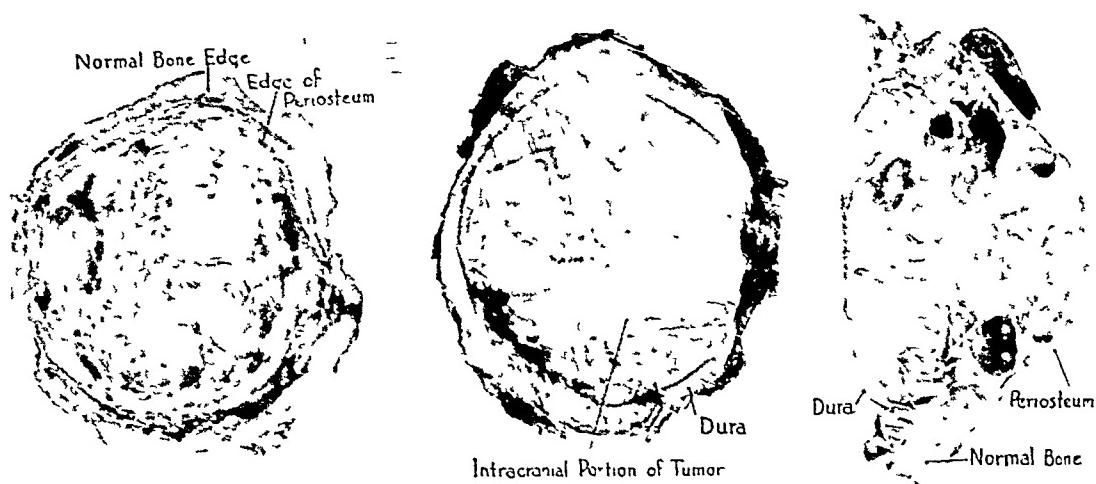
Fig. 5. Metastatic carcinoma of skull showing (a) extracranial, (b) cranial and (c) intracranial extensions; b, dura and intracranial portion of tumor; c, sagittal section of metastatic tumor mass

tumor gradually tilts from the nest that it has made in the cortex. (Fig. 3*b*.) If the tumor has not grown through the dura, it
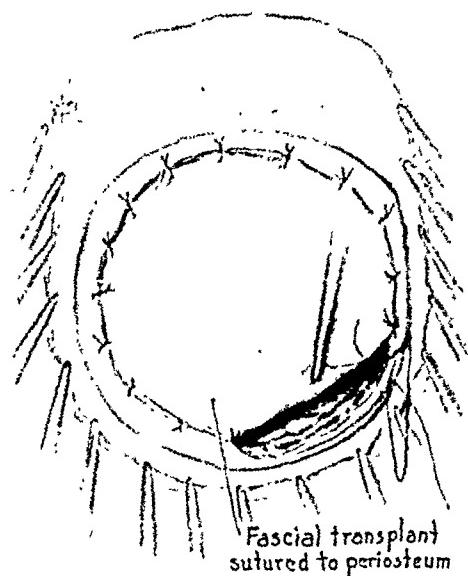
Fig. 6. Dural defect covered with fascial transplant.

readily is lifted from the cortex and perhaps only one or two cortical veins which enter need be occluded with the electrocoagulation and divided. However, if it has grown through the dura as in a meningioma, a few arteries will be encountered as well as the veins, and considerable care must be exercised in brushing the cortex from the tumor edge as traction is exerted on the dural edge. As the tumor is slowly tilted from its base the vessels can be readily occluded and divided. Photographs of specimens removed are shown in Figures 4 and 5.

After the entire mass has been removed, the dural edge remaining may be sutured to the periosteum avoiding chances of a postoperative clot. If the tumor is near the sagittal sinus and over the rolandic vein, it is unwise to suture the dural margin to the periosteum since it may occlude the channels in the dura by which rolandic venous blood enters, often causing sufficient stagnation for thrombosis to take place. This occurred in one of our cases.

If the tumor is definitely metastatic there is some question as to the wisdom of performing a plastic operation at the time the tumor is removed and the dural defect is repaired with a layer of fascia. (Fig. 6.) However, if a nonirritating substance such as a thin vitallium plate is at hand, it can be firmly anchored in place. If the tumor is a meningioma, a bone graft is probably advisable unless vitallium proves to be as satisfactory in the skull as in other bones of the body. Unfortunately, I have not used it but expect to have as nearly the exact size and shape necessary to cover a defect as can be determined at hand in the future. Its advantages, of course, are its lightness of weight, strength and elimination of any necessity of obtaining bone from other sources or from the immediate vicinity of the skull. The latter necessarily would increase the blood loss and time of operation.

SUMMARY

A method is demonstrated that allows complete extirpation *en masse* of a single solitary, destructive lesion of the skull, including extracranial and intracranial local extensions. This procedure has been carried out in four cases, with excellent technical results.

SUPPRESSION OF LACTATION BY STILBESTROL*

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ESTRONE and estrone-like substances are assuming an ever increasing rôle in the suppression and inhibition of lactation. Out of the welter of controversial reports by clinical and laboratory investigators,[2] the rationale for this type of therapy seems to be based on the physiologic suppression of the anterior pituitary, with the resulting inhibition in the production of the lactogenic hormone, variously designated as prolactin,[1] mammotropin[6] and galactin.[7] Mayor,[3] Ramos and Colombo,[4] and a host of others obtained gratifying results with the natural estrogenes.

Dihydroxydiethyl stilbene, commonly called stilbestrol, possesses the same pharmacologic activity as natural estrogenes although chemically unrelated. Because of its marked therapeutic efficacy by oral administration, its use is enhanced in the inhibition of lactation. This is evidenced by an ever growing number of reports in both American and foreign journals. Of still greater importance is its apparent freedom from toxic effects on the parturient. Greenhill,[10] believes this to be due to a special tolerance possessed by the postpartum patient.

Obviously, there are numerous occasions when the suppression of lactation becomes a necessity. The indications are not only those relating to postpartum maternal morbidities, but, in this streamline age, the physician is often compelled by the patient to institute such measures because of economic and social reasons. In this series of cases, forty or about 37 per cent demanded such therapy, whereas twenty-six or 23.6 per cent were actually due to maternal debilities.

ANALYSIS OF 110 CASES

Method. The greater number, in this series, were private patients under the supervision of their own physicians. The administration of stilbestrol was under the care of our supervisor of nurses, who allotted the drug to the patients at the request of the attending physician. A record of each case was kept on each individual chart as long as the patient was in the hospital. Reactions were carefully watched for and recorded by the nurse in charge on each floor. The following table outlines the indications for the suppression of lactation.

TABLE I

A. Maternal Debility Due to:
    1. Postpartum hemorrhage............. 2
    2. Anemia due to placenta previa........ 1
    3. Secondary anemia.................. 1
    4. Bronchial asthma................. 1
    5. Postpartum infection.............. 1
    6. Cardiac disease................... 3
    7. Acute mastitis.................... 2
    8. Toxemia......................... 9
    9. Following cesarean section........... 4
    10. Postpartum psychosis 1
    11. Previous mastitis................... 1   26
B. Refusal to Nurse for Social or Economic Reasons........................... 40
C. Inverted, Tender or Fissured Nipples........ 24
D. Fetal Causes:
    1. Still-births and neonatal deaths....... 10
    2. Unable to nurse (immaturity)........ 10   20

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Following the dosage suggested by Mucklé,[11] stilbestrol was administered orally in tablets of 5 mg. three times a day for two days or a total of 30 mg. to the first 103 patients. The next seven patients were given 45 mg. at the same rate of 15 mg. per day. It is noteworthy that no other adjunct therapy was used; no restriction of fluids, no tight breast

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binders, no massage or stripping of the breasts, no atropine, no camphorated oils and no saline cathartics, during the administration of this drug.

TABLE II

ANALYSIS OF RESULTS

Dose: 30 mg. (15 mg. for two days)

Days Postpartum	No. Cases	No. with Total Relief	No. with Return of Lactation			
			No. Requiring Added Stilbestrol	No. Given MgSO4	Total	No. with Pseudolactation
1st and 2nd	20	16	1	3	4	4
2nd and 3rd	19	16	1	2	3	4
3rd and 4th	27	25	1	1	2	8
4th and 5th	14	14	0	0	0	6
5th and 6th	13	12	1	0	1	1
6th and 7th	3	3	0	0	0	2
7th and 8th	4	4	0	0	0	2
8th and 9th	1	1	0	0	0	1
9th and 10th	1	1	0	0	0	1
5th week	1	1	0	0	0	1
Total	103	93	4	6	10	33
Per cent	...	90.29	..	..	9.71	33.8

Fortunately, the author was able to follow up the entire group of patients, due to the co-operation of the attending physicians, who kept him informed of the progress of each case even after the patient had left the hospital. From the above analysis, it is obvious that in this series there was absolute failure in about 10 per cent of the cases. Early in the study, several co-operating physicians administered magnesium sulfate to six patients as adjunct therapy without the knowledge of this investigator. Since the outcome of the treatment of these six cases is problematic without this meddlesome therapy, they are included with the absolute failures. About one-third of the cases had a recurrence of some watery secretion approximately seventy-two hours after the administration of the last dose. This occurrence may be termed pseudolactation, for the secretion was watery and disappeared without any therapy whatever.

A group of seven patients were given 45 mg. of stilbestrol in the same dosage as above. Although this group is too small to permit of an accurate estimate of the therapeutic effects of the greater dose, it tends to indicate that there is no need for any larger dosage. While there were no absolute failures in this group, pseudolactation occurred in about the same ratio. In addition, two patients complained of severe headaches, which promptly yielded to acetyl salicylic acid. Whether or not these headaches were due to the drug is speculative.

One lactating patient developed acute mastitis five weeks postpartum. The attending physician administered 30 mg. of stilbestrol. About forty-eight hours after its administration, the acute mastitis subsided, the breasts became dry and a previous temperature of 104°F. became normal with no return of the condition.

Three other cases not included in this study were interesting enough to bear description. A cardiac patient was given 5 mg. about two days after delivery. Shortly thereafter she developed dyspnea, palpitation and nausea. It was deemed advisable to discontinue the drug in spite of the fact that the symptoms pointed rather to the cardiac condition than to the use of the drug. Another patient decided to nurse her baby after 15 mg. of the drug were given. There was no diminution in the quantity of the milk from this dose. Another patient with excessive lactation was given 14 mg. of stilbestrol to diminish the flow of milk In this it was entirely successful.

CONCLUSIONS

Stilbestrol successfully suppressed lactation in over 90 per cent of a series of 110 cases. It was found to be safe and easy of administration. No other therapy was necessary at the same time.

the stilbestrol and her co-operation in this study.

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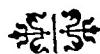
THE treatment of Hirschsprung's disease might be summarized by pointing out that no one method or combination of methods is uniformly satisfactory in all patients, and indeed it is almost impossible to obtain a complete cure in any of these children. However, this note of pessimism must not obscure the fact that close medical supervision, combined with one or more of the surgical procedures when specifically indicated, can appreciably increase the emptying power of the bowel and can greatly improve the general health of the patient.

From—"Abdominal Surgery of Infancy and Childhood"—by Ladd and Gross (W. B. Saunders Company).

Case Reports

SEGMENTAL ABDOMINAL HETEROTAXY

SITUS INVERSUS VISCERUM ABDOMINIS PARTIALIS*

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EXAMINATION of the entrails of man and beast is a practice old as antiquity. It is depicted in ancient manuscripts and biblical lore. In Egypt, a considerable knowledge of visceral anatomy had been obtained through the process of embalming, and the Israelites possibly carried with them some of this learning. The Bible gives directions for the dissection[1] of animals slaughtered in sacrifice and enumerates the specific abdominal contents[2] required for the altar. Inspection of the viscera of sacrificed animals was a prominent phase of divination, or augury. Among the Babylonians, soothsaying was concentrated in the liver[3] (hepatoscopy) and is mentioned in the Bible[4] wherein all such forms of divinations and necromancy are severely condemned.[5] However, the early Romans absorbed from the Etruscans a class of soothsayers whose art consisted especially in deducing the will of the gods from the appearance presented by the entrails of a slain victim. This art of haruspicy became highly developed. Its votaries were variably known as extispices (inspector of entrails), aruspices (entrail observers), or haruspices. They were held in high esteem at one time and Claudius even went so far as to establish a "collegium" of haruspices

presided over by an Haruspex Maximus[6] with a law of standards regulating their prophecies. To please the gods, the victim must be without spot or blemish and the variable visceral patterns presented the omens for interpretation and forecasting. In the course of events, it was inevitable that bizarre visceral anomalies would be noticed, commented upon and recorded. Transposition of the viscera may have been noted since the time of the ancients, evincing, as the case may be, joyous portents or grave forebodings.

Pure situs inversus (mirror-image) remains merely a medical curiosity except when it engenders complications in a pathologic process requiring surgical interference or when it presents a problem inherent to the heterotaxy itself. Situs inversus has long since ceased to be regarded as a rarity. Mass routine examinations by school, insurance, military and industrial organizations, coupled with the more frequent use of roentgenography and fluoroscopy, have uncovered numerous benign examples.

Partial situs inversus may occur in a system, an organ or a viscus. However uncommon a pure situs inversus remains, it is obvious that a partial heterotaxy is still more infrequent. Dexicardia represents

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the greatest percentage of this type. Abnormal position of the intestinal tract is the result of some disturbance of migration, rotation, descent or fixation during the embryonic development of the alimentary canal. Most of these occur in the midgut, malposition of the fore- and hindgut being extremely rare. Dott[7] states: "Error in location or attachment of that part of the foregut situated within the abdomen (stomach and duodenum down to the biliary papilla) is excessively rare." Interest in this phase of the subject was stimulated when we presented a case that fell into the group of this rare type.

In former times, when necropsy material provided the only means of diagnosing the condition, Risel[8] (1909) reported two cases of his own and collected several varieties of partial heterotaxy involving different segments or group of segments of the body. Soleil[9] (1936) reviewed the entire subject of total and partial heterotaxy, discussing and classifying the various types. The case herewith reported falls into his classification of "interversion abdominale segmentaire sus-ampulaire (situs inversus abdominal partiel)," of which type he claims to have collected only four cases. Review of his bibliography, however, reveals that only two of these cases[10,11] are similar to ours; the others[12,13] are more a torsion of the stomach, or "volvus ventriculi" than a true transposition. We cannot accept Soleil's estimation of the incidence of this condition, since he failed to include Risel's[8] collection of several cases proved by specific necropsy findings.

In order to understand better this congenital anomaly, we believe it necessary to review briefly the early embryonic development of the intestinal tract, stressing particularly the foregut.

Developmental Embryology of the Foregut. The embryonic disk, composed of three germ layers, primarily lies flat upon the yolk sac. The first indication of the alimentary tract is the entodermal vesicle of the zygote. By a constriction, the vesicle becomes divided into an intra-

embryonic portion (the future alimentary canal and its appendages) and an extra-embryonic portion (the yolk sac); the
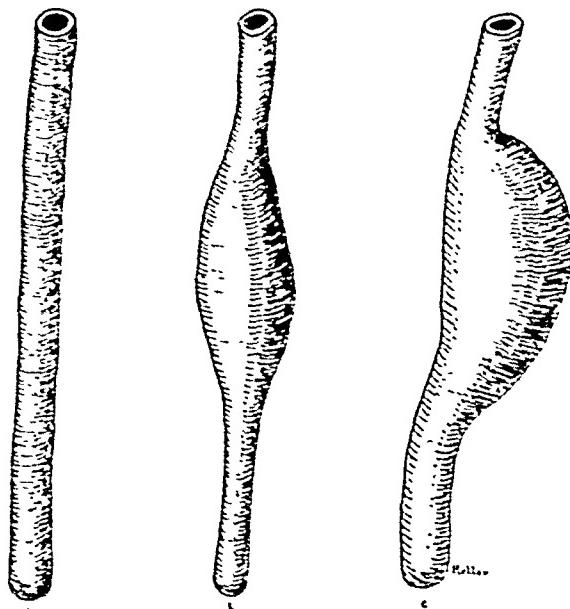
Fig. 1. Schematic diagram representing three stages in the differentiation of the mammalian stomach. a, Early undifferentiated stage in which the stomach appears as a tube of uniform caliber; b, spindle-shaped gastric dilatation; c, typical mammalian eccentric gastric dilatation. (After Huntington.)

intervening constriction is the vitello-intestinal duct. As the embryo elongates, the alimentary canal takes the form of a tube and its subdivisions become apparent.

The intestine rapidly becomes elongated and three regions are recognizable. The cephalic portion, extending as far as the opening into the yolk sac is called the foregut. The portion over the opening is the midgut. The caudal portion, as far forward as the opening into the yolk sac, is the hindgut. In subsequent stages the subdivision is based on form, the parts constituting three distinct loops. It is based upon the blood supply; this is distinct for each part: the celiac axis, superior mesenteric and inferior mesenteric arteries, respectively. It is largely applicable to function: the foregut, digestive; the midgut, absorptive; the hundgut, excretory. In subsequent stages, the point where the liver arises marks the caudal limit of the foregut; the left colic flexure marks the cephalic limit of the hindgut. In the mean-

time, the midgut grows longer, while the communication with the yolk sac has become relatively much smaller and
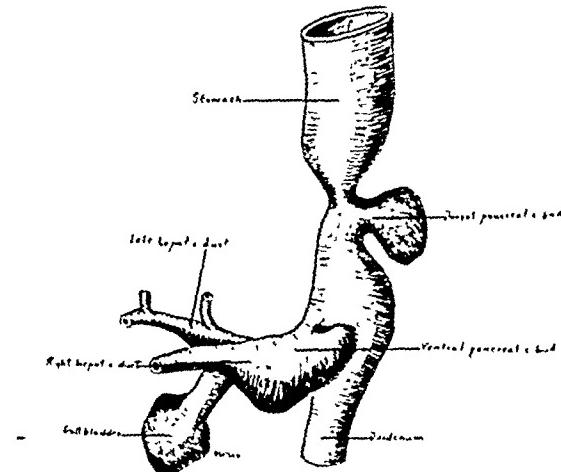
FIG. 2. From a reconstruction of the anlagen of the liver and pancreas and a part of the stomach and duodenum of a human embryo of four weeks. (After Felix.)

appears as a slender structure, namely, the yolk stalk, attached to the midgut. All are suspended by the common dorsal mesentery. A ventral mesentery extends between the ventral abdominal wall and the ventral surface of the intestinal tract, forming a partition which divides the body into a right and left half.

Stomach. The abdominal portion of the foregut forms the stomach and the duodenum down to the biliary papilla. The anlage of the stomach can be recognized in embryos of 5 mm. as a slight spindle-shaped enlargement of the primitive gut a short distance cranial to the yolk stalk. The dilatation goes on more rapidly on the dorsal than on the ventral side, thus producing the greater and lesser curvature, respectively. (Fig. 1.) The greater curvature is attached to the dorsal body wall by the dorsal mesogastrium, which is part of the common dorsal mesentery. The lesser curvature is attached to the ventral body wall by the ventral mesogastrium. (Fig. 3.) At this time, the stomach presents a right and left surface, a ventral concave border (the lesser curvature) and a dorsal convex border (the greater curvature), with the esophageal

entrance at the cephalic end of the organ, while the pyloric transition occupies the distal, caudal extremity. In further devel-
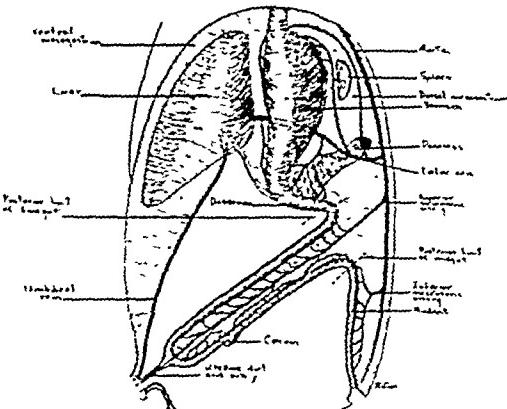
FIG. 3. Diagrammatic representation of the embryologic alimentary tract, its appendages and blood supply, showing its anatomic and functional division into foregut, midgut and hindgut. (Modified after Sabotta.)

opment, the greater curvature becomes much more prominent and the organ as a whole changes its position, the latter process beginning in embryos of 12 to 14 mm. The cephalic (cardiac) end moves toward the left side of the body, the pyloric end towards the right. At the same time, the stomach rotates, the greater curvature turning caudally from its dorsal position. The result is that the organ comes to lie in an approximately transverse position in the body, with the cardiac end to the left, the pyloric end to the right, the greater curvature directed caudally and the lesser curvature directed cephalad.

Duodenum. The segment of small intestine situated between the pylorus and the beginning or point of departure of the proximal or descending limb of the umbilical loop, develops into the duodenum. This portion of the small intestine is indicated early in embryos of 2.15 mm. Somewhat later, in embryos of 4.10 to 5 mm. in length, it becomes additionally marked by the origin of the pancreatic diverticulum. The duodenum, at first straight (Fig. 2), now begins to curve, forming a short duodenal loop or bend. In embryos

of six weeks, the duodenum forms a simple loop placed transversely below the pyloric extremity of the stomach. Its mesentery fuses with the peritoneum of the dorsal body wall and the duodenum thus becomes a fixed portion of the intestinal tract. (Fig. 3.)

Liver and Gallbladder. In point of time, the liver is the first accessory structure to develop by budding from the primitive alimentary canal. In embryos of about 3 mm. a longitudinal ridge-like evagination develops from the entoderm on the ventral side of the gut a short distance caudal to the stomach, that is, in the duodenal portion of the gut. The cephalic part of the evagination is solid and, being destined to give rise to the liver proper, is called the pars hepatica. The caudal part is hollow, its cavity being continuous with the lumen of the gut, and is destined to give rise to the gallbladder; hence, it is called the pars cystica. Beginning at both the cephalic and caudal ends, the evagination as a whole becomes constricted from the gut until (in embryos of about 8 mm.) its only connection with the latter is a narrow cord of cells which is the anlage of the ductus choledochus. The pars hepatica, by this time, has enlarged considerably and remains attached to the ductus choledochus by a short cord of cells, the anlage of the hepatic duct. The primitive hepatic duct is directed cephalad in the mesogastrium between the vitelline duct and the stomach. (Fig. 2.)

In embryos measuring 4.25 mm. the duct is 0.24 mm. long. Later (in embryos of 8 mm.) the primitive single duct divides into two secondary branches, indicating, even at an early stage, the adult arrangement of the duct, as formed by the union of the right and left hepatic ducts.

The pars cystica has also become larger, its distal portion being somewhat dilated, and is connected with the ductus choledochus by the anlage of the cystic duct. (Fig. 2.) The pars cystica grows into the ventral mesentery and thus becomes surrounded by mesodermal tissue. The proxi-

mal portion continues to elongate to form the cystic duct and the distal portion becomes larger and more dilated to form the gallbladder. (Fig. 2.)

The parts hepatica, or anlage of the liver proper, also grows into the ventral mesentery, thus becoming surrounded by mesodermal tissue. The mesodermal tissue gives rise to the fibrous capsule of Glisson and to the small amount of connective tissue within the gland.

Although the liver develops as a series of outgrowths from the original evagination, there are certain features in its development which distinguish it from glands in general. The outgrowths come in contact with the omphalomesenteric veins which are situated in the ventral mesentery. They push their way into and through the veins, breaking them up into smaller channels. They anastomose freely with one another and the veins send off branches which circumvent these channels. Thus there is formed a network of trabeculae of liver cells, called hepatic cylinders, the meshes of which are filled blood vessels. Therefore, the liver is distinguished from other glands in general, in that the hepatic cylinders, which are comparable to the smaller ducts and terminal tubules of other glands, anastomose, and in that the blood vessels are broken up by the growth of these cylinders.

All the blood carried to the liver by the omphalomesenteric veins must follow the tortuous course of the sinusoids before being collected again and passed on to the heart. When the umbilical veins come into connection with the liver they also join in the sinusoidal circulation. Subsequently, however, a more direct channel—the ductus venosus—is established and persists for a short time. This is probably due to the large volume of blood brought in by the umbilical veins. Finally the ductus venosus disappears and the sinusoidal circulation remains as the permanent form.

The lobes of the liver develop in a general way in relation to the great venous trunks which, at one time or another, pass

into or through the gland. The anlage of the organ grows into the ventral mesentery, subsequently becoming enclosed in the septum transversum. In so doing, it encounters the omphalomesenteric veins, and forms, in relation to the latter, two incompletely separated parts which have been called the dorsolateral lobes. When the umbilical veins enter the liver, a more ventral, medial mass is formed. This becomes incompletely separated into two parts which give rise to the permanent right and left lobes. The right becomes the larger. The right umbilical vein loses its connection with the liver. After birth, the left, which lies between the right and left lobes, degenerates into the round ligament of the liver. The other lobes arise secondarily as outgrowths from the right primary dorsolateral lobe, the caudate (lobe of Spigelius) from its inner (medial) surface, the quadrate from its dorsal surface.

The liver, as a whole, grows rapidly and by the second month is relatively large. During the third month it fills the greater part of the abdominal cavity. After the fifth month it grows less rapidly and the other intra-abdominal organs overtake it, so to speak, although at birth it forms one-eighteenth of the total weight of the body. After birth it actually diminishes in size, comparatively. The right lobe is from the beginning larger than the left, and after birth the predominance increases.

Pancreas. The epithelium of the pancreas, like that of the liver, is a derivative of the entoderm. It arises from two (or three) separate anlages, one dorsal and one (or two) ventral. The dorsal anlage appears first as a ridge-like evagination from the dorsal wall of the gut, slightly cephalad to the level of the liver. (Fig. 2.) It appears about the same time as the liver or a little later. (In embryos of 8 mm. (four weeks) it appears as a small spherical outgrowth connected by a slightly narrower stalk with the epithelial intestinal tube.) The mass of cells grows into the dorsal mesentery and becomes constricted from the parent epithelium except for a

thin neck which becomes the duct of Santorini. A little later two other diverticula appear from the epithelium of the primitive hepatic duct, and not directly from the duodenum. This distal ventral outgrowth is from the beginning closely connected with the similar embryonic outgrowth from the enteric tube which is to form the liver. The diverticulum continues to develop and becomes constricted from the parent epithelium, leaving only a thin neck which becomes the duct of Wirsung, which is closely connected with the end of the common bile duct at the intestinal opening common to both.

The smaller ventral pancreas grows to the right and then dorsally into the mesentery, passing over the right surface of the portal vein, until it meets and fuses with the proximal part of the larger dorsal pancreas. In embryos of the sixth to seventh week, the two glandular outgrowths have become fused into a single mass at a point which corresponds exactly to the divergence of the duct of Santorini from the main pancreatic duct (duct of Wirsung) in the adult gland, the ventral anlage giving rise to the head, the dorsal anlage to the body and tail of the pancreas. A communication is established between the two ducts, and the dorsal duct (Santorini) usually disappears, leaving the ventral (Wirsung) as the permanent duct opening into the ductus choledochus. (Fig. 3.)

As the pancreas grows into the dorsal mesentery it lies in the dorsal mesogastrium between the greater curvature of the stomach and the vertebral column; and since the dorsal mesogastrium at first lies in the medial sagittal plane, the pancreas is similarly situated. After the sixth week, however, as the stomach changes its position, the pancreas is carried along with the mesogastrium and comes to lie in a transverse plane, with its head to the right and embedded in the bend of the duodenum, and its tail reaching to the spleen on the left. (Fig. 3.) The organ as a whole is at first movable along with the

mesentery, but when it assumes its transverse position, it lies close to the dorsal abdominal wall. The mesentery then fuses with the adjacent peritoneum and the pancreas is firmly fixed.

The connective tissue of the pancreas is derived from the mesodermal tissue of the mesentery. As the processes or buds which form the ducts and terminal tubules grow out from the primary masses, they penetrate the mesodermal tissue and are surrounded by it. Groups of tubules form lobes and lobules and the entire gland is surrounded by a capsule of connective tissue.

Spleen. The first anlage of the human spleen appears early in the fifth week. It is represented by a triangular cellular elevation in the left side of the dorsal mesogastrium opposite the urogenital fold and to the left of the pancreas, at the level of the fundus of the stomach. (Fig. 3.)

The ultimate origin of the spleen is not yet settled and the details of its later development are still obscure. For some time, the spleen was considered as a derivative, primarily, of the mesenchyme in the region of the dorsal mesogastrium. More recently, however, investigators have taken the view that it arises partly, or possibly entirely, from the mesothelium (celomic epithelium) of the dorsal mesogastrium. In the human embryo, during the fifth week, the anlage of the spleen appears as an elevation. This elevation is produced by a local thickening and vascularization of the mesenchyme, accompanied by a thickening of the mesothelium which covers it; furthermore, the mesothelium is not so distinctly marked off from the mesenchyme as in other regions. Cells from the mesothelium then migrate into the subjacent mesenchyme and the latter becomes much more cellular. The migration is brief, and in embryos of about forty-two days migration has ceased and the mesothelium is again reduced to a single layer of cells. The elevation becomes larger and projects into the body cavity. At first it is attached to the mesentery

(mesogastrium) by a broad, thick base, but as development proceeds, the attachment becomes relatively smaller and finally forms only a narrow band of tissue through which the blood vessels (splenic artery and vein) pass.

DISCUSSION OF EMBRYOLOGY

The configuration of a human embryo of a few millimeters is symmetrical on a median sagittal plane, the right and left sides being mirror images of each other. By atrophy or excessive development of a certain part, by rotation, torsion or migration, an internal asymmetry is produced which identifies the right from the left side. Various phases of visceral rearrangement of the abdominal portion of the foregut occurs in the course of the first few months. The rarity of true malposition of the foregut and hindgut as contrasted to developmental errors in the disposition of the midgut (the intestine from the biliary papilla to the left third of the transverse colon) is due to its less complicated evolution and its natural disposition in the abdomen.

It seems that the vertical position and the physiologic differentiation of the upper extremities, which are prehensile organs in the human and not supporting organs as in the quadrupeds, involve a flattening of the anteroposterior direction and necessitate this visceral rearrangement. Certain vertebrates, such as the cat, conserve the median arrangement to the adult state.

Various theories as to the causes of transposition of the organs have been advanced. The explanation of total situs inversus may be hypothesized on the old theory of Serre and Forster, based upon the formation of "double monsters." Serre,[14] in 1832, showed a determining rôle in the unilateral atrophy of the omphalomesenteric artery, producing an asymmetric development of the liver. If the left lobe were evolved in the location of the right lobe of the liver, there might result a subdiaphragmatic interversion.

But whether this interversion would be confined to this segment cannot be assured. The primary origin of the asymmetry is still lacking.

In the most plausible theory the anomalous condition is considered due to the influence of the large venous trunks in the abdominal region, especially on the position of the liver and stomach.

Primarily, the omphalomesenteric veins pass cranially through the mesentery. Later they form two loops around the duodenum. Then the left half of the upper ring and the right half of the lower disappear, the common venous trunk thus following a spiral course around the duodenum. After the veins come into connection with the liver, the right vein atrophies and the left increases in size and becomes the single, large umbilical vein of later stages. The right lobe of the liver becomes the larger. If, as is maintained by some investigators, the usual position of the stomach and liver is due to the persistence of the left venous trunks, a persistence of the right venous trunks instead would afford a plausible explanation of the transposition of these organs. Certainly, a reversal in the position of the stomach would cause a reversal in the position of the duodenum and its derivatives. Since only the abdominal portion of the foregut is developed in conjunction with these venous trunks, it is not unreasonable to attribute the transposition of the stomach, the duodenum and its derivatives (liver and pancreas) and other associated organs (the spleen), directly or indirectly to the persistence of the right venous trunks, without disturbing the development and position of the remainder of the intestinal tract.

We are unable to state or to quote any authority which can plausibly hypothesize what disturbing influence tilts the balance of asymmetric development. The factor producing such anomalies is probably present in the defective fertilized ovum. In a majority of cases, transposition of the viscera causes no disability and, at first sight, there appears to be no reason why it should not be as common as the normal position; for when there is no selective advantage or disadvantage between a dominant and a recessive, they may occur in any proportion in a population and still remain in equilibrium.[15] However, there appears to be much evidence that transposition of the viscera is associated with other congenital anomalies—atresia of the duodenum, polycystic kidney, congenital morbis cordis, absence of, or multiple spleens. Anomalous lobulations of the spleen (lien lobatus), such as was present in our own case, are not rare, and are fully explicable by the multilobular embryonal anlage. Congenital lobulations of the topography of the spleen are usually dependent upon other malformations. A case of multilobular spleen with transposition of the viscera has recently been reported.[16] Besides such congenital malformations, heterotaxy appears in frequent association with a syndrome of hypertrophic rhinitis, nasal polyposis, sinusitis and bronchiectasis, more frequently than can be accounted for by chance.[17]

A linguiform enlargement which may protrude from under the lower margin of the larger lobe of the liver is known as Riedel's lobe. The lobe may have a broad base of attachment, such as was found in our own case, or may be connected to the liver by a thin pedicle. Its occurrence is more common in women than in men, and it is often attributed to the effects of tight lacing or the wearing of a tight belt around the waist. But since it has occasionally been found in quite young children, it must be regarded rather as an anatomic abnormality.

CASE REPORT

Mrs. F. K., a white female, age forty, married, was admitted to the Urologic Service of the Beth-El Hospital, August 21, 1938, complaining of upper abdominal pain of two weeks' duration. The patient had suffered from flatulence and "sour stomach" for the past ten years.

Menses began at the age of fourteen, were regular, of the twenty-eight-day type and lasted about four to five days. She did not suffer from menorrhagia or metrorrhagia; menopause occurred at the age of twenty-six.

Palpitation on exertion was her only complaint referable to the cardiovascular system. Seven years ago, she had been a patient at another hospital where she was treated for epigastric distress and at that time a mass was found in the epigastrium. There was no venereal history.

Physical examination revealed that the patient was fairly well nourished, mentally clear, intelligent and quite co-operative. Blood pressure 130/90; temperature 99°F.; pulse, 84; respiration, 22. The neck presented bilateral scars of previous incisions. The lungs were negative to percussion and auscultation. The heart was in the left side of the chest; apex beat was in the fifth interspace, three and one-half inches from the midline but otherwise was essentially negative. Abdominal examination revealed a tender mass in the left upper quadrant, extending from the left subcostal margin to the level of the umbilicus which, on percussion, was found to extend laterally to the left flank. A dull note was elicited over the entire mass. The lower margin of the tumor mass was round and discrete. The remainder of the abdomen was flaccid. Some tenderness was also elicited on palpation in the right iliac fossa. The splenic edge was not palpable. The right kidney was not felt. The left kidney, on palpation, could not be distinguished from the mass. Rectal and vaginal examinations disclosed a uterus smaller than would be expected for her parity. Neurologic examination was negative.

Blood chemistry studies were within normal limits. Wassermann and Kahn tests were negative. Urine, plus 2 albumin, otherwise negative; red blood cells, 6,200,000; hemoglobin, 17 Gm.; coagulation time eight and one-half minutes; platelet count 350,000; fragility began at 0.42 and was complete at 0.34; white blood cells, 18,000; staff neutrophiles 6 per cent; segmented neutrophiles 86 per cent; eosinophiles 2 per cent; lymphocytes 3 per cent; monocytes 3 per cent.

A retrograde pyelogram showed both kidneys normal in size and shape. The left kidney appeared to be high in the abdomen but the urographic outline was normal. Mass density was noted in the left midabdomen and was extrinsic to the renal shadow. When these roentgenograms were interpreted by Dr. M. Dannenberg, he was of the opinion that we were dealing with a case of transposition of
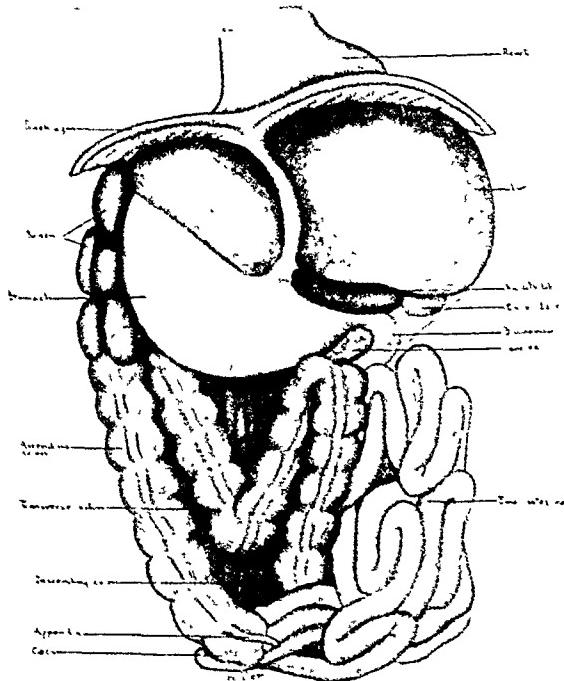
Fig. 4. Diagrammatic representation of the anatomic topography as constructed from operative findings.

viscera. The gas shadow in the right upper quadrant (Fig. 5) he believed represented the outline of the stomach and suggested a gastrointestinal series. However, the patient was operated upon before his report was received. Clinical diagnosis: Retroperitoneal neoplasm.

Operation was performed on August 29, 1938, under spinal anesthesia. The abdominal cavity was opened through an upper left rectus-splitting incision. Exploration revealed that the left vault of the diaphragm was occupied by the larger lobe of the liver which was markedly enlarged. A rounded tumor mass, 10 cm. long by 5 cm. in width, soft in consistency and of a darker hue than the liver, was found adherent to the undersurface of the transposed right lobe of the liver. The rounded edge of this tumor mass extended about 3 cm. below the free border of the liver. The examining fingers could be hooked around a free posterior pole of the tumor mass which was presumed to be a Riedel's lobe. In the angle between the outer margin of this ectopic lobe and the free lower margin of the liver was found a globular, collapsible body, surrounded by omentum except for its superior surface which was thought to be the gallbladder. The viscus was carefully separated from its bed of adhesions by sharp

and blunt dissection and a cholecystectomy was performed.

Further exploration by palpation and direct

FIG. 5. Preoperative roentgenological genito-urologic study, showing the magenblasse on the right side.

vision revealed the left kidney to be of normal size and shape, situated high, at about the level of the ninth rib. The spleen was absent from the left upper quadrant and was found in the right upper quadrant. It consisted of five separate lobes. The stomach and duodenum were transposed to the right side of the abdomen. The gallbladder was transposed to the left, as previously mentioned. The head of the pancreas was felt to the left of the midline in the curve of the duodenum. The cecum and appendix occupied the right lower quadrant and the rest of the abdominal viscera were in their normal positions. (Fig. 4.) The uterus was atrophied, as had been noted on vaginal examination and the adnexa were negative to palpation.

A cigarette drain was placed in the liver bed, leading to the stump of the cystic duct and brought out at the upper angle of the wound. The abdomen was closed in layers. The patient was returned to the ward in good condition.

The first two postoperative days were uneventful except for a moderate rise in temperature, associated with slight abdominal distention. The drain was removed on the third day. The wound healed per primam except at the

site of drainage. On the fourth postoperative day, the patient was distressed by gradually increasing abdominal distention, accom-

FIG. 6. Gastric roentgenogram showing transposition of the stomach and duodenum with the cardiac shadow in the left chest.

panied by vomiting of small amounts of yellowish fluid, which was relieved by gastric lavage. She was passing flatus. From then on, the postoperative course became stormy and was marked by distention, vomiting and a gradual rise in temperature to 103.8°F. on the tenth day, pulse 120, respirations 28. Distention and vomiting increased, no flatus was being expelled and, in spite of everything that could be done, she continued to go downhill and died on the twelfth postoperative day, with a clinical diagnosis of paralytic ileus. An autopsy was requested, but refused.

Pathologic Report of Gallbladder. Gross: The specimen was 11 cm. long, had a glistening serosa and contained thin bile. The wall was delicate. The inner aspect presented a typical bile-stained, intact mucosa. Microscopically, the section showed mucosal folds, lined by columnar epithelium and muscularis characteristic of the gallbladder.

The patient's demise precluded our intentions to investigate her intestinal anomaly and all our efforts to obtain a postmortem examination in order to elaborate upon our operative findings, were unavailing. We made a search

into the patient's past history and located her previous hospital record at the Jewish Hospital, Brooklyn, New York, from which the following pertinent data were extracted.

She had been admitted, October 30, 1931, with a clinical diagnosis of chronic cholecystitis. Subsequent examination revealed a mass in the epigastrium and a tentative diagnosis of neoplasm of the stomach or transverse colon was made. A gastrointestinal series (No. 79,953), taken November 7, 1931, was reported as follows: "The stomach is transposed. It is J-shaped and considerably ptosed, without evidence of intrinsic disease. The pyloroduodenal region is normal. The large bowel rests entirely in the right abdomen and the sigmoid extends well up on the right, probably beneath the diaphragm. Aside from the anatomic abnormality, no pathology is observed." (Figs. 6 and 7.)

An attempt to locate the liver was made by cholecystographic visualization (No. 80,121), November 11, 1931. "The gallbladder was visualized by means of a radiopaque dye and was found to be situated on the left side. There is a constriction in the region of the fundus noted on three films, suggestive of the presence of pericholecystic adhesions. The organ is completely empty at the 36-hour study. There is no radiographic evidence of a concretion in this region." Roentgenologic Diagnosis: Situs inversus of the liver.

The operative findings were corroborative of these roentgenologic reports. Confirmation of our clinical localization of the heart being in its proper position was demonstrable by a chest roentgenogram (No. 80,222, November 11, 1931) the report of which showed "the heart is not transposed." She was discharged with a diagnosis of transposition of the abdominal viscera.

DISCUSSION

The accuracy of the topographic diagnosis of abdominal diseases depends upon the assumption that the viscera occupy their normal position. But this is not always the case. All the abdominal viscera are liable, in more or less degree, to displacements, some of which date from birth, while others are acquired in later life.

The surgical importance of abnormal situation of abdominal portions of the alimentary tract requires little comment. It is of importance to the correct diagnosis of abdominal pathology. Thus, if left-

FIG. 7. Roentgenogram of the colon showing the cecum and appendix in their normal locations on the right side of the abdomen.

sided appendicitis has not been considered, disasterous consequences may result, while a normally situated organ would have been removed by timely operation. The same may be said of the gallbladder, although malposition of this viscus is rare in comparison. Failure to recognize the nature and characteristic features of these misplacements may lead to grave errors in procedure, or to injurious prolongation of the operation, or even its abandonment.

In surgery of infants, the condition acquires an especial significance, owing to the difficulties of abdominal diagnosis by exploratory celiotomy, and the probability of pathologic consequences of maldevelopments is greatest in them.

In exploratory operations upon the alimentary tract, it is important that abnormal dispositions of the viscera be recognized and further search made in

order to become oriented properly. Thus, in operations designed to apply to a particular portion of intestine, as in gastrojejunostomy, recognition of anatomic abnormalities is of great importance.

We believe an appeal should be made to the surgeon to take cognizance of the organs in the chest cavity in his physical examination as well as to those in the abdomen, for the discovery of a dexicardia may sometimes be associated with a situs inversus, thereby saving the surgeon from an embarrassing position and a state of chaos at the operating table. It is our belief that when an abnormality of the abdominal viscera is discovered, the examining physician should relate his findings to the patient and supply him with a detailed report of his examination. In the event that the patient should require subsequent treatment elsewhere of a surgical nature, at which time a complete roentgenologic survey of the abdominal viscera might not be feasible, the surgeon, having this record of the previous findings on hand, would be guided by this information in his diagnosis and operative procedure.

SUMMARY

1. Heterotaxy or congenital transposition of the internal organs does not constitute an exceptional anomaly, while segmental hetarotaxy is relatively rare.

2. Normal embryologic development of the primitive alimentary canal, with emphasis on the foregut, is briefly reviewed.

3. The pathologic consequences of anomalies of the alimentary tract are discussed as to their relative frequency, embryologic origin and surgical significance.

4. A case of segmental abdominal heterotaxy with multilobular spleen and a Riedel's lobe of the transposed right lobe of the liver is reported.

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SARCOMA DEVELOPING IN AN OLD BURN SCAR*

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THE relation of trauma to tumor formation has been frequently discussed in considering the etiology of neoplastic diseases and numerous cases are on record citing this causal relationship. Although there appears to be firm ground for accepting this relationship clinically, we have little scientific evidence for this assumption. Hausemann insists that there is no scientific explanation for the development of neoplasm following acute trauma. Ramm, in speaking of sarcoma specifically, holds a similar opinion, although he admits the probability of trauma-tumor sequence from a histological point of view. The great difficulty in proving this relationship lies in our inability to prove the causa generis of malignancy, the frequently long latent period between trauma and tumor formation, and the fact that although accidents and trauma are very common, cancer follows in an infinitely small proportion of these cases.

Since this is true, we naturally ask why should cancer follow certain injuries while most trauma does not result in tumor formation. In answer to this question Fenster states that there are only two known biological procedures leading to tumor formation with any degree of certainty, namely, embryological and regenerative processes of growth and repair. He further states that it is generally recognized that most tumors have their origin in the so-called embryological anlage—the "germ" of the tumor; nevertheless, it appears that some tumors arise from an acquired germ anlage (as for example those originating in scars). At any rate every tumor has its origin in a germinal anlage; a fully matured cell of the body is not transformed into a tumor cell, and neither does the reverse process occur.

The acquired "germ" anlage is important in demonstrating the connection between trauma and tumor for it is based on a repeatedly disturbed regenerative process following primary tissue alteration. The factor of predisposition to tumor formation is an important if little understood quantity, and may be either general or local in nature. This, too, may be congenital, but occasionally is an acquired property.

Cancer developing in scars is well known and comprehensive reports and discussions have been contributed by many authors. A large series of cases of burn scar cancers have been reported by E. F. Neves, of Kashmir, India, smaller series being recorded by Roffo and Gandolfo, of Buenos Aires, and Treves and Pack, of New York City. Ewing's postulate for burn scar cancers, quoted by the latter authors, still stands as the measuring rod for this relationship:

"a. Incontrovertible evidence of burn as shown by the wound or resultant scar.

"b. The law of localities which purports that the cancer must originate within the boundaries of the burned area.

"c. The absence of any precursory or similar neoplasm on the site of the burn prior to the development of cancer.

"d. The histological variety of the cancer must be compatible with the tissue found in thermal wounds and scars, e.g., squamous cell carcinoma in the majority of instances and basal cell occasionally in superficial burns.

"e. The interval of time between the date of burning and the onset of cancer

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must be proper (more important for single acute trauma than for burns)."

According to Roffo and Gandolfo, the

FIG. 1. Photograph showing tumor of posterior surface of left thigh and benign ulceration of posterior surface of right thigh. Note dense scar tissue with contracture over right popliteal region.

development of cancer in a burn scar is the result of isolation of epithelial cell "nests" subsequent to scarring. These remain dormant until certain irritating processes occur, such as trauma, endocrinological influences, etc., when after repeated stimulation neoplasm occurs. Lumiere, in discussing cancer as a cicatricial disease, states that nearly all skin cancers develop on scars and that a scar could be discovered as the basis for every case of skin cancer if looked for carefully. Only a few scars develop cancer, however, and these result under the following circumstances: (a) Prolonged healing of the wound; (b) old scars (twenty to thirty years); (c) secondary trauma to the scar; (d) humoral predisposition. Chronic irritation or infection

of a scar results in repeated destruction and reproduction of epithelial cells. These cells finally acquire the special capacity for reproduction without the aid of an outside stimulus and growth becomes unrestrained.

Neves, in speaking of Kangri burn cancers specifically, stated in a personal communication to one of the authors (R. M. F.) that he was inclined to regard the heat waves rather than the products of combustion as the exciting cause of cancer in these cases. This brings heat waves into line with x-rays, etc., further along the spectrum, as a cancer producing factor.

Leriche believes that sclerosis of the vessels of the skin is necessary for the development of skin cancer. Winkler emphasizes the importance of the variation between cells and cell groups in their ability or inherent predisposition to become neoplastic. Hoffman points out that certain irritations prepare the cell for the development of cancer by maladjustment of tissue behavior; when an endogenous factor as above is combined with this, cancer then develops.

The type of cancer developing in a scar is predominantly epithelioma, and of the epitheliomas, squamous cell grade I or II is the usual histological picture. Treves and Pack reported only six basal cell carcinomas in a series of twenty-eight burn scar cancers, and of this number three were classified under "acute" wound cancer, that is, developing less than a year after the accident. These authors believe that basal cell carcinoma is more likely to develop early after superficial burns which spare the hair follicles and sweat glands, as in burns from hot solids. However, a divergence of opinion is expressed by Stauffer, who believes that the abnormally early appearance of cancer following a burn may be related to the existence of a precancerous condition of the affected area prior to injury. He cites instances in which this has occurred, and subsequent examination revealed precancerous conditions of other areas of the skin, such as senile keratoses, leukoplakia, etc.

Sarcoma following injuries is well known although infrequent. Sarcoma developing on scars is rarer still, except that type cause an imitation of the immature cells of connective tissue. As Bosnajkovic traces the process, scars subjected to repeated

Fig. 2. Photograph shows extent of scarring which completely encircles both thighs.

originating on old lupus scars. In none of the series of burn scar cancers reported was sarcoma mentioned. Neves knows of no case in his experience with thousands of burn scar cancers in which sarcoma developed. Most of the reported cases of sarcoma in scars has followed war wound injuries. Ramm has examined many reported cases and finds that most of them do not survive critical survey. This author suggests that the same factors which tend to produce carcinoma in scars are probably responsible for the development of sarcoma: namely, irritation from thermal, chemical, mechanical or infectious sources. Since sarcoma is a neoplasm of the cells of mesenchymal tissue origin, the results of such irritation or other influence applied to these cells will

irritations resulting in constant destruction and regeneration of cells may become the site of benign proliferation of the connective tissue. This may take the form of a keloid or fibroma. In the beginning it is often difficult, even histologically, to distinguish between benign connective tissue proliferation and early sarcomatous transformation. An irritation which under ordinary conditions would be expected to produce a benign proliferation might produce sarcomatous transformation under certain circumstances. This may occur when the tissue in question contains misplaced embryonal cells (theory of Cohnheim and Berman), or an area transformed by a postembryonal mechanism to special susceptibility (Krompecher). Such an irri-

tation may transform cells into a labile stage, sensitizing them to further stimulus. If this irritation is prolonged, autonomous
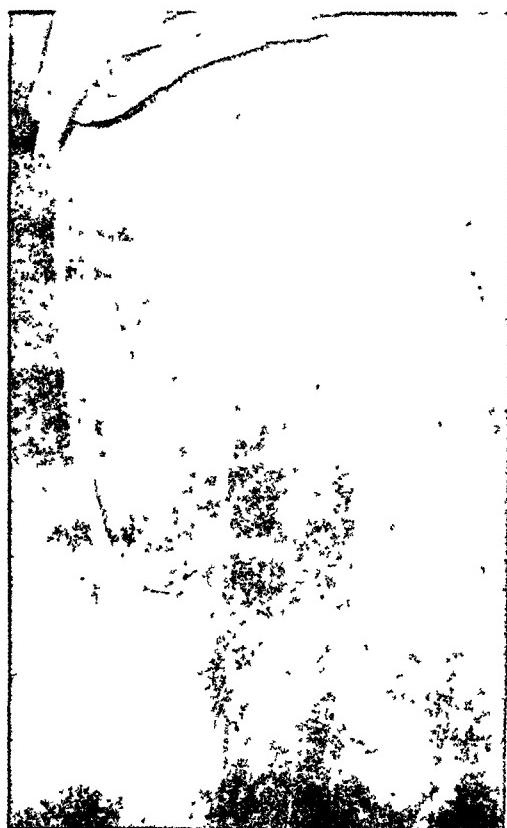
FIG. 3. Photograph shows extent of endotherm excision. Muscle fibers can be seen in deeper portions of the wound.

proliferation with loss of restraint occurs and sarcoma develops (Borst).

It is of great interest that so few of the scar cancers reported are sarcomas. Why this should be is not altogether clear although it is fair to assume that the epidermis is subjected to more trauma than the connective tissue and, therefore, must undergo the process of repair much more often than the deeper layers of the epithelium and subcutaneous tissues. Whatever the reason, sarcoma developing in burn scars must be quite rare as we were unable to find any reported case, verified histologically, in our search of the literature. It is true that certain articles dealing with trauma and tumor were not accessible to us and it is possible that these articles might cite such cases. Since preparing this paper two other sarcomas developing in the skin following trauma have been seen in our department.

The following case is reported in detail because of the unusual histological picture of sarcoma developing in a burn scar:

CASE REPORT

E. W., fifty-four years of age, a white married male, was seen in consultation with Dr. A. G. Levin on May 15, 1939, because of recurrent ulcerations and tumor formation in old scars of both thighs. The patient had fallen in a bonfire forty-nine years previously at the age of five years and sustained severe burns of both thighs, anteriorly and posteriorly, as well as the posterior surface of both legs. He was treated by tub baths and traction for nine months with healing, by scar formation, taking place very slowly over a period of several years. Pinch grafts were applied over the knees only. Apparently the posterior surfaces of the thighs were burned most extensively, as healing was never complete; here heavy dense scarring occurred with recurrent ulcerations and abortive attempts at healing. The ulcerations on the right thigh became so painful and irritated that in 1914 the patient consulted a doctor who applied pinch grafts. This thigh finally healed completely by 1926 and remained healed for twelve years.

The lesion on the left thigh has never been completely healed at any time but has shown tendencies to improve rapidly for a short time only to break down and ulcerate widely.

In September, 1938, (eight months prior to this first visit) the patient went to Pikes' Peak where he experienced a severe sunburn of the thighs with vesicle formation. Following this the right thigh again became ulcerated in several areas. At this time the ulcer on the dorsum of the left thigh began to enlarge and tissue proliferated above the skin level. This grew steadily until the tumor reached the size of "half a tennis ball."

Examination at this time revealed no pertinent findings other than the lesions of the thighs. There were no palpable nodes. There was diffuse scarring of both thighs involving the entire circumference. However, the posterior surface of both thighs presented an extremely thickened, indurated, reddened area of scar tissue extending from below the gluteal

crease to the upper popliteal region which showed numerous ulcerated areas with secondary infection. On the left thigh, in the center

with the deep fascia that it was necessary to sacrifice the muscular fascia. An area 15 cm. in width by 17 cm. in length was excised. A
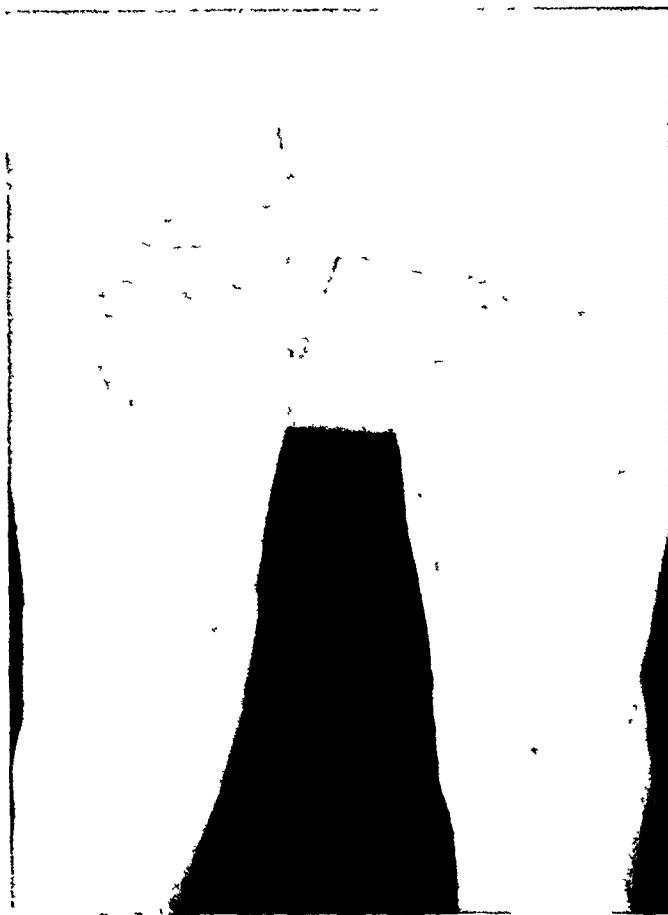
FIG. 4. Photograph six months following first graft. Thick split grafts of posterior surfaces of both thighs and right popliteal space. Note minimal skin changes over buttocks despite the fact that the same donor site was used for all three grafts at different times.

of the ulcerated region, was a tumor mass measuring about 3 by 4 cm. and projecting 2 cm. There was a dense contraction over the right popliteal space which prevented extension of the right leg.

Laboratory findings were normal and the chest x-ray was negative.

Biopsy of the tumor of the left thigh was done on May 22, 1939, and revealed a sarcomatous process.

Operation was then performed by one of us (R. M. F.) on May 27, 1939, under spinal anesthesia. With the cutting current of the endotherm, wide excision of the entire thickened area on the dorsum of the left thigh was done, the excision being carried down to the fascia investing the muscles of the thigh. In some areas, especially along the medial border, the scar tissue was so intimately associated

biopsy was taken from the ulceration of the right thigh. A "Z" plastic was attempted in the right popliteal region but the tissue was so dense and avascular that it was impossible to approximate the triangles after undermining was done, and a defect was left over the popliteal space to be closed later with full thickness skin graft.

Pathological Examination. The specimen consisted of a piece of skin measuring about 10 by 15 cm. in diameter. A belt of normal skin measuring about 4 cm. in width surrounded an elevated area which was firm in consistency, presenting an irregular surface. The cut surface showed a grayish-white tumor tissue invading the subcutaneous fat tissue.

Sections showed neoplastic cell tissue which consisted of spindle cells differing markedly in size, form, shape and color. There were large

numbers of mitoses noted, and an impaction of the vessels. Secondary degenerations in form of hyalinization and necrosis were also noted.

these areas epithelialized rapidly after the necrotic tissue was removed. By August 30, 1939, the entire grafted area had the appear-

FIG. 5. Excised tumor. Grayish-white nodules in the star-like scar.

An inflammatory reaction was present which consisted of leukocytes and lymphocytes. Diagnosis: Spindle cell sarcoma.

The wound was allowed to granulate to the skin level and the patient returned to the hospital on July 7, 1939, for skin grafting. The previously excised area in the posterior surface of the left thigh left a defect 15 cm. in length by 12 cm. wide. The surface was covered with clean, healthy, granulation tissue. In the right popliteal space, at the site of the previous "Z" incision for release of contractures, the margins of the wound had sloughed away and a defect 6.8 cm. in length by 3.3 cm. in width remained. This was covered with a healthy, granulating surface. The right leg could now be fully extended.

The granulating surface was shaved away with a sharp knife and the margins of the wound undermined about 3 or 4 mm. The defect was outlined with a rubber tissue dam and transferred to the skin of the buttock where thick split grafts were removed with the Blair-Brown skin suction apparatus and transferred to the defect. The graft was sutured about the margins with interrupted sutures of black silk No. 7. A sponge rubber pressure dressing was applied. The defect in the right popliteal area was similarly treated and multiple partial thickness skin grafts were applied and sutured in place. A moist sponge pressure dressing was then applied.

Only a small portion of the margins of the grafts showed any evidence of necrosis and

ance of normal pliable full thickness skin and there was no evidence of disease.

A biopsy of the ulceration of the right thigh revealed no evidence of malignancy. However, excision of the entire ulcerated area was deemed advisable as a prophylactic measure. This was done on the other thigh. This graft was similarly successful.

On March 11, 1940, the patient returned for a routine follow-up at which time the left thigh showed a completely healed normal appearing skin graft. The right thigh was likewise completely healed, only a small area at the lateral border being covered with a superficial crust. However, the patient stated that three weeks previously he first noticed a painless lump in the left groin which grew rapidly to the size of a hens egg almost overnight. It had remained stationary since that time. Examination showed a nodular mass in the left inguinal region with several surrounding smaller masses. Extending directly above this was a still larger fixed intra-abdominal mass about 3 by 6 cm., apparently fixed to the lateral pelvic wall.

A biopsy of the inguinal mass was taken. Sections of the gland showed the entire gland to be completely replaced by very poorly differentiated neoplastic tissue. Most of the cells were arranged in whorl-like forms. The nuclei were either spindle or ovoid. They invaded the walls of the vessels, and a tremendous number of neoplastic mitoses as well as giant cells, were noted. In other areas,
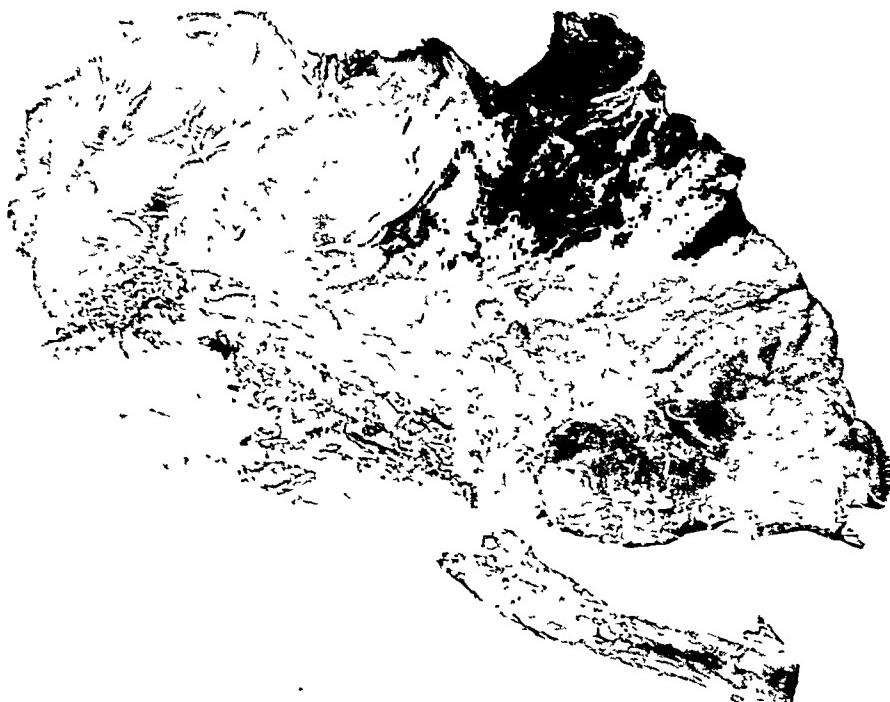
Fig. 6. Section of the skin through scar and tumor formation. Epithelium and cutis partly replaced by dense tumor infiltration, low power.
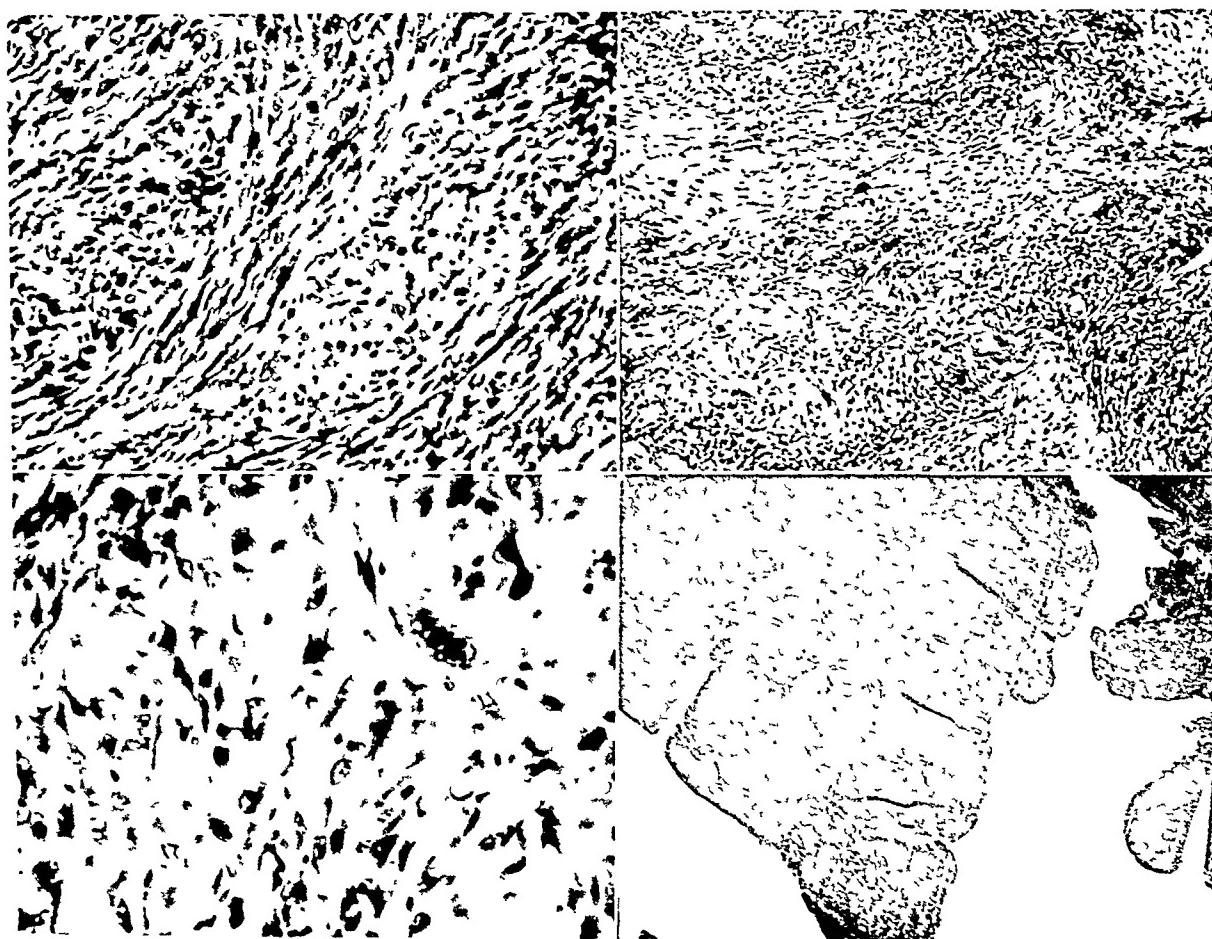
Fig. 7. Superficial layers of tumor tissue, medium power; spindle cells. Cells differ in size, form and shape.

Fig. 8. Deeper layers show the tumor more edematous in character. Some myxomatous cell forms are present.

Fig. 9. High power of deep layer of tumor; low grade of maturity, giant cells.

Fig. 10. Section of the inguinal lymph gland, low power. Entire gland practically completely replaced by tumor tissue.

however, these neoplastic cells were so poorly differentiated, and showed such an unspecific arrangement, that the sarcomatous character
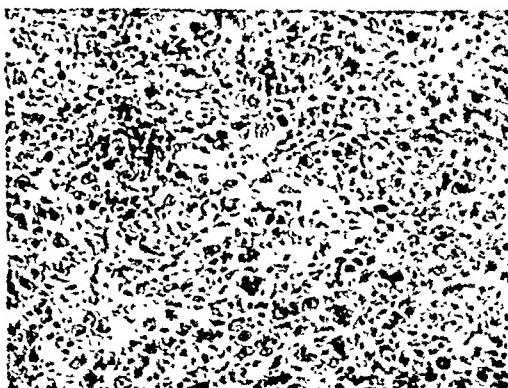
FIG. 11. Section of inguinal lymph gland, high power; cells of rather low grade of maturity; marked difference in size, form and shape; giant cells and mitoses.

was even doubtful, although the diagnosis of sarcoma was sure due to the findings in other parts of the slide. Diagnosis: Metastases of sarcoma in a lymph gland with very poor differentiation, and a high degree of anaplasia.

He was immediately referred to Dr. Levin for x-ray therapy but the patient deferred this until April 12, 1940. At this time the examination was the same as at the previous follow-up.

Following an intensive course of radiation to the inguinal and femoral regions and lower left abdominal quadrant, there was prompt regression of the masses.

By July, 1940, the skin reaction from x-ray had completely subsided and the patient had no complaints. There were no masses palpable in either the abdomen or inguinofemoral areas. No evidence of disease was found. X-ray of the chest was again negative for metastases.

The patient remained symptom-free until the latter part of September, 1940, at which time he complained of a slight pain in the right chest of several days' duration. Examination revealed a few râles in the lower axillary region. Within thirty days a friction rub appeared in this region and later a nonproductive cough, dyspnea and low grade fever developed. At this time a recurrence of the mass was noted in the left subinguinal region which gradually enlarged until the time of his death.

He required repeated thoracenteses to relieve the dyspnea associated with a bloody pleural effusion of the right pleural cavity. About two weeks prior to death he developed symptoms of partial intestinal obstruction which con-

dition was one of the factors in the causation of his death. It was believed that the probable extensive involvement of the retroperitoneal nodes, as well as the abdominal viscera, rendered surgical aid unfeasible. The patient expired on January 8, 1941.

Summary of Chief Findings at Autopsy. Skin: There was a small metastasis to the anterolateral aspect of the left thigh and a smaller metastasis to the right scapular region. Peritoneal Cavity: A moderate amount of bloody fluid was present in the peritoneal cavity. Diffuse irregular nodules were scattered over the entire peritoneal surface and omentum. Gastrointestinal Tract: The gastrointestinal tract showed compression of the splenic flexure of the colon due to numerous enlarged lymph glands in the mesentery. There were multiple areas of adhesions between the loops of small bowel; its mesentery, and the peritoneum, producing many partially obstructed areas. Liver: The liver revealed multiple nodular metastases. Spleen, Pancreas, Kidneys and Adrenals: The spleen, pancreas, kidneys, as well as the adrenals, showed no evidence of metastases. Sex Organs: With the exception of a moderate prostatic hypertrophy, the sex organs were without evidence of pathology. Thoracic Cavity: The thoracic cavity showed a bloody pleural effusion on the right. The pleura on this side showed thickening of both layers and partial replacement by tumor masses. The right lung was grossly suspicious of metastases. The heart showed a moderate coronary sclerosis. Histological Sections: In none of the sections taken from the autopsy material was the histological structure identical with that of the primary tumor. Nowhere was the spindle cell character of the primary tumor observed. All of the sections showed more similarity to the picture seen in the section from the biopsy of the lymph-node, viz.; very poorly differentiated neoplastic cells with numerous mitoses and giant cells.

DISCUSSION

This case illustrates the importance of early proper care of burns including skin grafting. It also demonstrates the inadequacy of pinch grafts over large areas or over areas subject to trauma.

It is regrettable that an inguinal node dissection was not done at the time of

excision of the primary lesion; this might have prevented recurrence. Since, however, the tumor was quite vascular and sarcomas metastasize typically by the blood stream, we elected to omit dissection.

It is interesting to note that a relatively mature fibrosarcoma produced rapidly growing anaplastic metastases. This accounts for the excellent though temporary response to radiation therapy.

SUMMARY

A case of fibrosarcoma developing on an old ulceration in a burn scar of forty-nine years' duration, is reported.

The tumor was treated by wide endotherm excision followed by thick split skin grafts. The patient remained completely well for nine months, before developing anaplastic metastases to the inguinal and iliac nodes. The metastases were temporarily controlled by radiation therapy, and the patient showed no evidence of disease for four months after treatment. Diffuse general metastases occurred after this period, however, and the patient succumbed nineteen months following his original operation.

Carcinoma developing in burn scars is not uncommon, but sarcoma is extremely rare as we were unable to find another reported case, verified histologically.

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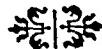
MARJOLIN'S ULCER*

REPORT OF A CASE

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WITH military preparedness now under way our attention is directed toward the problems of military reconstructive surgery and how best to cope with them. One of these problems is the question of burns. It is here that we find a vast field for prophylactic surgery. During the first World War many severe burns, including those from explosives as well as aviators burns, were treated. It would be expected that such types of burns would be considerably more numerous in this present war. We may still see, in our time, further complications arising from the burns of the last war, as it has been demonstrated that the small percentage which shows degenerative changes on through to malignancy occurs from four months to thirty-two and one-half years later.

In 1828, Marjolin described the pathologic picture of malignancy occurring in burn scars. For many years it was called Marjolin's ulcer. The original description as it appeared in "Dictionnaire de Medecine pratique" is as follows: "La surface de ces ulcères est formée par un tissu composé d'un grand nombre de villosités coniques, d'une texture dense, serrée, trés rapprochées les unes des autres, représentant en quelque sorte un velours de laine groosier. Ces ulcérations laissent suinter en petite quantité un fluide visqueux presque incolore, fétide, qui en se desséchant forme une croûte épaisse, dure, grisâtre, trés adhérente. Ils sont peu douloureux au même indolents et susceptibles de prendre une grande étendue."

These ulcers may remain for a great many years as simple chronic ulcers before the insidious malignant change occurs. This usually begins at a portion of the margin and spreads slowly and progressively though usually only a portion is malignant, the remainder being non-malignant. The edges are raised and indurated, the center may be filled with granulations, some healthy, some sloughing and grayish in color. They exude a thick colorous viscid fluid which upon drying forms a thin crust which bleeds when removed. The odor is usually foul. There is evidence of healing in spots where the cancerous tissue has sloughed to a normal base. One important feature of these ulcers is that they are painful and the pain is described by Paget as "hot, scalding and of a darting character." By this time the floor of the ulcer and margins have become greatly indurated and the floor appears wavy, like a velvet plush. The lymph channels are blocked by the induration and metastasis occurs late. The age of the scar is more important than the age of the patient.

The prevention of burns is beyond our power but after the burn has once been received, much can be done to eliminate the inevitable sequellae. The primary treatment is of paramount importance in avoiding infection and thus promoting a good granulating surface, most desirable for skin grafting.

It would appear safer to clean up any infection which usually exists, before exploring the depth and nature of the growth. A biopsy can then be safely done and a thorough excision accomplished to a safe depth and width, preparatory to skin grafting.

Treves and Pack collected over a twelve-year period 1,091 patients with epidermoid carcinoma of the skin and 1,374 patients with basal cell carcinoma. In twenty-eight instances these carcinomatous growths developed on the basis of burn scars, new and ancient; twenty-one were epidermoid carcinomas and seven were basal cell carcinomas. From these figures they estimated that about 2 per cent of all epidermoid carcinomas and 3_{10} per cent of all basal cell carcinomas originate on the skin which has been subjected to thermal injuries of all types.

In 1902, DaCosta reported two cases of Marjolin's ulcer in which he spoke of this pathologic entity as a rare condition. Strauss described two of his cases in which x-ray and radium treatment probably played a factor in the carcinoma which developed in burn scars.

Attention is also called to the Kangri burn cancer of India which results from the wearing of small charcoal stoves under the loose garment of the natives. It is stated that forty-five operations annually are performed for this type of carcinoma alone. Similar to the Kangri burn is the Kairo burn cancer of the Japanese resulting also from the wearing of a small portable stove for body warmth.

From these cited statistics we observe that, although the cases are comparatively few as compared with burns as a whole, we are nevertheless dealing with a clinical entity which may lead to a disastrous termination if not recognized and dealt with properly.

As stated before, everything possible should be done to obtain a good granulating surface. Then, when conditions warrant, this surface should be covered with a suitable skin graft, thus eliminating the train of infection, fibrosis, thick unyielding avascular scar and contraction. Then comes a period of freedom of clinical symptoms only to be followed months or years later by repeated abrasions or irritation of the scar with poorer healing qualities each time, until the epithelial stimulation

has been such that it now has reached neoplastic proportions.

It is indeed fortunate that this neoplasm is situated upon such a fibrous, avascular base. Because of this, metastasis to the regional lymph glands is very slow and late, and the chance of a cure is favorable. Conversely, when the neoplasm breaks through this avascular scar its growth is extremely rapid and usually proves fatal after two years.

X-ray has proved of some use in the preoperative treatment of the basal cell cancers but neither x-ray nor radium has any affect upon the squamous type.

The case under discussion should be of interest for the following reasons: first, because of the age of the patient and the length of time intervening between the reception of the burn and the inception of carcinomatous changes occurring in the scar—a period of some thirteen years; second, because of the similarity to Marjolin's ulcer both in the gross and microscopic; and third, because of the difficulties encountered over a period of years before the contractions were relieved, the infection was controlled, the skin grafts were applied and the patient was apparently cured. The report of the case follows:

CASE REPORT

In December, 1926, when K. N. L. was four years old he was playing with a flaming broom. The left pocket of his playsuit was nearly full of matches of the nonsafety type. These became ignited and caused a deep eschar over the left groin varying in density as it approached his left chest, part of the left arm to the elbow and down the left leg on its anterior and lateral aspects to the knee.

It was treated with oil and later on, with salt solution for nearly four months when pinch grafts were applied to the remaining granulating area. A curious fact is that these grafts were taken from both the father and the mother. The patient states that his father's graft would not take but that his mother's proved satisfactory. At least they "stemmed the tide" until epithelization intervened. X-ray treatments were given weekly for the

next thirteen months with the idea of softening the dense scar tissue.

No further treatment was needed until 1928

kinds, the ulcer healed in a desultory manner, only to break down late in 1939, when the patient returned, this time with an ulcer twice
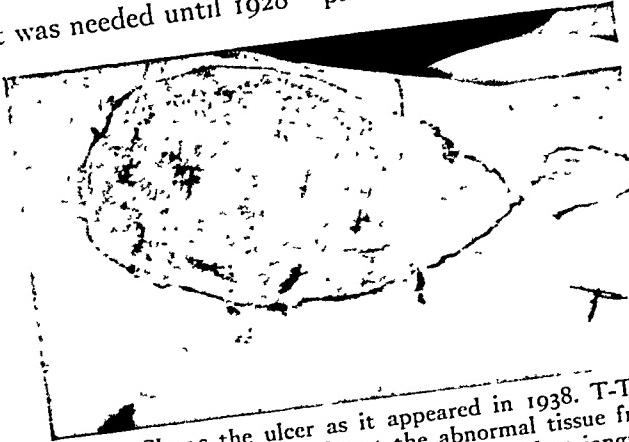
FIG. 1. Shows the ulcer as it appeared in 1938. T-Trochanter. Ink lines mark out the abnormal tissue from the scar tissue. The two small marks show the triangular area which, more or less, was grafted successfully with deep pinch grafts in order to epithelize the ulcer and thus help combat the infection.

when contraction of the scar in the groin, plus the growth of the child, caused him to bend forward at an angle of sixty degrees in order to walk. At this time the dense scar in the groin and in the axillary fold was cross cut and undermined, and apparently allowed to granulate in. A cast with windows in for dressings was applied from the axilla to the knee. This cast was left on for some six months. After its removal, the legs of the patient appeared to be of equal length and the incisions appeared to be satisfactorily healed. Growth and contraction again took up the slack and by 1932 the patient was walking at an angle even greater than the earlier one. This time two full thickness grafts were applied, one taken from the anterior surface of the right thigh and the other from the good skin of the abdomen. One graft was applied to the area of the left lower quadrant and the other over the upper and inner third of the thigh. It is presumed that some of the scar was removed at this time. Part of one of these grafts was lost which necessitated a Thiersch graft to complete this operation.

Again in 1935 a "Z" plastic was preformed by this last surgeon to relieve a slight contraction in the groin.

The patient consulted me in 1938, at which time there was an ulcer about 4 cm. in diameter and 10 cm. below the trochanter with rather punched out margins. (Fig. 1.) There was some infection with a slight tendency to granulate in. After two months of applications of various

its previous size located near the old site. The ulcer was punched out with a sloughing base, rounded edges piled up and undermined. Considerable infection was evident and a culture showed anerobic and aerobic hemolytic streptococcus and staphylococcus plus pyocaneus. Getting this under control was a genuine problem. The usual method for combating infection including the use of sulfanilamide were all tried. Results were best obtained by following the method of Meleney, namely, the application of zinc peroxide. One day the granulations would appear healthy; a few days later some of them would be in an unhealthy condition. The undermined edges were slowly breaking down in some areas while eivdences of healing occurred in others. The infection as a whole was receding; signs of epithelization were almost nil. A few deep pinch grafts were applied in the upper part of the ulcer which had now reached 6 by 10 cm. in size. The granulations were fairly clean and nearly all the grafts took with some impetus toward epithelization. However, some infection still remained.

Early in February the granulations and base took on a different hue within the center of the large ulcer. The change occurred at the original site of the scar area which first broke down. It is here that the description of Marjolin's ulcer enters the picture: the grayish velvet plush, conical vellosities and crust accompanied by pain of a burning nature, bleeding, etc.

Again the patient was hospitalized in February, 1940. The area was Dakinized for a few days and then gently scrubbed with soap and

Fig. 2. Shows the area after the first débridement down to the fascia lata. The remaining tissue is composed of granulation interspersed with carcinoma.

water, as advocated by Blair, Brown and others, in order to rid it of pyocaneus. It was determined, and a culture substantiated the opinion, that a débridement with cautery would be safe. This was accomplished and time was bided until a thorough pathologic study could be made regarding the nature of the

down to the muscles. This tissue was sent to the laboratory where sections were cut out and the specimen was lettered and photographed
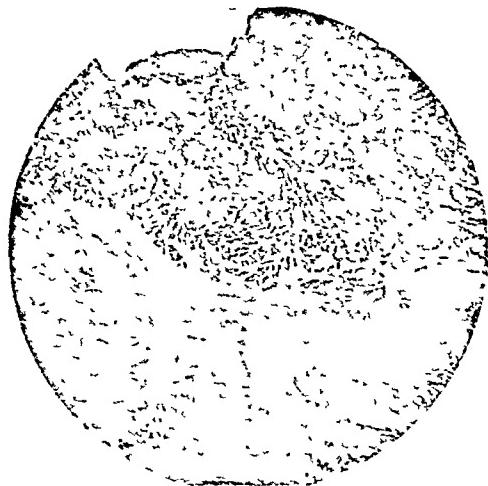
Fig. 3. Epidermoid carcinoma invading granulation tissue at the base of the old burn scar. None of the carcinoma was found to have gone completely through the fascia lata.

as shown in Figure 4. As can be seen, the section was thoroughly gone over, and when the report came back negative for carcinoma we believed that a split skin graft could be applied with fair certainty of no recurrence since there was no adenopathy. (Fig. 5.) The base
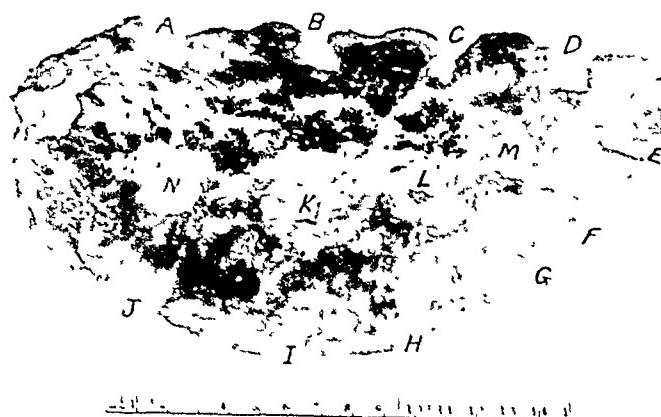
Fig. 4. The specimen shown was dissected out en masse down to the muscles. Areas which appeared suspicious of carcinoma were cut out and labeled so that should carcinoma be found in the deep layer the exact area could be determined.

tissue and its extent. The pathologic report returned epidermoid carcinoma grades 1 and 11. (Figs. 2 and 3.)

We had not gone sufficiently deep nor wide enough as all about the area the scar was still decidely thick. The skin ulcer this time was dissected en masse including the fascia lata

had a healthy layer of granulations over its entirety. With Padgett's dermatome, approximately three drums of skin .016 of an inch thick were cut from the right leg and right chest. This thickness, we believed, in a boy of seventeen should provide a good covering with fair certainty for a "take." The grafts were

sutured on with interrupted Deknatel No. C and left long on the edges. The separate grafts were overlapped and sutured. A few stab inci-

that most of the tissue which looked doubtful previously, was saved, as is shown in Figure 6.

During this time the donor sites were covered
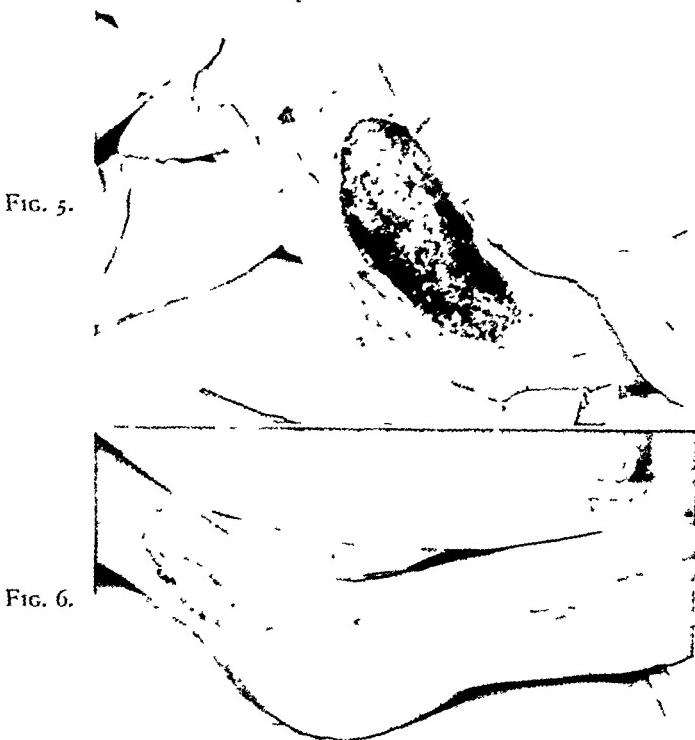
FIG. 5.

FIG. 6.

FIG. 5. Shows the area after final débridement which is now covered with a healthy layer of granulations and is ready for grafting.

FIG. 6. Showing the area ten days after grafting with .016 of an inch split graft. The graft took in its entirety except at the upper pole where pressure was difficult to obtain. Most of this was saved by the prompt use of Dakin's solution.

sions were made for drainage. Three per cent xeroform gauze was cut to pattern and several layers were held in place by means of tying the long sutures across the graft. More gauze was smoothly applied and a Dakin's tube was incorporated in the dressing. This whole dressing was held in place with bandages and elastoplast. With this Dakin's tube the dressing was continuously irrigated with 3 per cent boric acid solution and was not disturbed for eight days. The stitches were then removed. The edges were painted with 5 per cent Gentian violet and redressed with zeroform gauze, etc., as before. The graft looked well except that at its upper pole where it was difficult to obtain pressure. Dakin's solution was used for three days, at the end of which time it was discovered

with parresined gauze, 3 per cent xeroform ointment, gauze and elastoplast. They were again dressed at the end of a week and healed in from fifteen to twenty days, with no complications.

In the lower left quadrant x-ray telangiectases and scaling were beginning. It was noted that a slight contracture was developing in the left anterior axillary fold. In view of the previous experience it was decided that this tissue should be removed at a later date, thereby allowing the patient to get into better physical condition. In July of this year he returned to the hospital for what we hope is his final plastic repair. This time the x-ray telangiectases were removed and the axillary scar released and undermined. With the Padgett machine a section of skin, three by eight inches and .018 of an

inch thick, was taken again from the right leg, cut to pattern and inserted into this denuded area. The dressings were essentially the same as before and the result was a 100 per cent "take." Incidentally, there was microscopically a suspicion of carcinomatous changes, but since all scar tissue was deeply removed, I doubt if any concern regarding neoplastic recurrence is justified.

The patient can now stand erect. The scar tissue is replaced by a mobile, elastic, normally functioning skin which gives freedom over the area of the trochanter which heretofore was covered by a thick, inelastic, immobile and avascular tissue, a tissue which had all the prerequisites for the degeneration of scar tissue, irritation, infection and resultant neoplastic changes or Marjolin's ulcer. (Fig. 7.)

COMMENT

If our present day knowledge had been available in the beginning I am sure that this case would have been managed differently. As soon as the primary shock was under control and a granulating stage of the burn was reached, no doubt Thiersch grafts would have been applied, if only to check fluid loss in order to prevent infection and to promote epithelization. Undoubtedly, thicker grafts, by necessity of the contracting Thiersch grafts, should have been inserted here and there. The patient would have been spared the suffering during childhood plus the ultimate neoplastic results. Furthermore, changes in x-ray technic have now greatly removed the possibilities of overdosage.

For my patterns I have been using a heavy cotton flannel material used for padding under table cloths. This material will not shrink appreciably upon boiling and when placed directly upon the blood-stained recipient area, an exact replica can be cut out. A four spout Dakin's tube is used, connecting the two outside and the two inside tubes with a sufficient length of Penrose tubing to form loops of satisfactory size to cover the graft. Holes are burned in every quarter to one-half

inch. This tubing is so pliable that when incorporated in the dressing no harmful pressure can be exerted upon the graft.

Fig. 7. Shows the final result after grafting. At the present time a year has elapsed with no recurrence of malignancy.

By this closed tube arrangement the dressing is kept moist (at eight drops a minute) regardless of the position of the patient or the location of the graft. In my opinion, careful attention to such details reaps its rewards in its final result.

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RIEDEL'S THYROIDITIS

A REVIEW AND REPORT OF TWO CASES

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IN 1894, and again two years later, Riedel described before the International Congress of Surgery, a new pathological entity of the thyroid which created considerable interest. However, in 1864, Semple and in 1884, Bowlby had already described a case with clinical and pathological features very similar to those subsequently noted by Riedel. This disease has since been described also under the following nomenclature: Infiltrating Fibroma of the Thyroid (Bowlby), Eisenharte Strumitis (Riedel), Primary Canceriform Inflammation of the Thyroid (Berry), La Thyroiditis Ligneuse (Delore and Alamartine), and Benign Granuloma of the Thyroid (Ewing).

This varied nomenclature, though seemingly different, relates to a disease which is comparatively rare. Until 1926, thirty-three cases were reported by twenty-three authors and until July, 1939, we were able to find 141 cases which appeared to be typical cases of Riedel's strumitis. In this article, only cases which have established beyond a doubt the pathological picture, grossly and microscopically, have been accepted as typical of Riedel's strumitis. Cases reported as Hashimoto's disease have not been included for reasons which will be given later. From a study of the enclosed tables, it will be seen that there has been an increase in the number of cases reported in recent years due, no doubt, to the fact that more thyroidectomies have been performed and more complete pathological studies made. It is also interesting to note that regardless of geographical distribution there has not been a very great variation of the incidence. Inasmuch as this disease is so important in a consideration of the differential diagnosis and treatment between it, malignancy and Hashimoto's disease, its importance cannot be over emphasized. The average incidence in thyroidectomies of 0.2 per cent is sufficiently low to warrant a more recent review of the subject and the report of two new cases.

CASE REPORTS

E. A., age forty-six, a white female housewife, was first seen May 3, 1939. Her chief complaint was swelling of the neck for about two years. There were no other instances of goiter in the family. Except for her father dying of pulmonary tuberculosis, the family history was negative, and the past history was irrelevant.

For the past two years, the patient thought her health had been poor. She believed that she had had a goiter for two years, but the onset was so slow and gradual that she was not fully aware of its actual presence until relatively recently. At times, she had felt nervous and irritable. On occasion, she had noticed some palpitation, usually following some exertion. Recently, she began feeling a sense of weight and pressure in the neck and at the same time became aware that her goiter was extremely hard. Sometimes, she would have paroxysms of coughing lasting a short time. There was no dysphagia. The patient stated that she had lost fifteen to twenty pounds in weight during the past month.

At the physical examination the patient appeared to be considerably underweight. The examination of the neck revealed a fairly symmetrical enlargement of both lobes of the thyroid, measuring about 5 by 4 cm. The surface was smooth and the whole goiter moved easily on deglutition. There was no apparent fixation to surrounding structures. No glands were palpable. The most impressive feature of the examination was the stony hardness of the entire goiter. The clinical diagnosis was probably malignancy of the thyroid.

On May 11, 1939, the patient was operated upon under evipal and gas-oxygen anesthesia. At operation, the goiter was found to be so hard that it was only with the greatest difficulty that it was possible to place hemostats as the resection was proceeding. It was quickly realized that a classical thyroidectomy leaving the posterior capsule was technically impossible. Only about half of each lobe was, therefore, resected. There was little bleeding.

Pathological report: Macroscopic examination: The specimens labled "thyroid" measure 45 by 25 by 20 mm. and 35 by 20 by 20 mm. Their free surfaces are bosselated and upon cross section, greyish white and extremely hard homogeneous tissue is revealed.

Microscopic examination: The stained sections show that the thyroid tissue has been entirely replaced by an extensive fibrosis, in which numerous tubercles are present. These tubercles which consist of numerous giant cells and occasionally with epitheloid cells, though atypical in structure, excite the suspicion of a possible tuberculosis of the thyroid. The macroscopic characteristics of the specimen, however, do not support this diagnosis, but excite the suspicion that we are dealing here with a so-called "Riedel's Struma."

A search for a malignant process was made but resulted negatively.

Diagnosis: Riedel's Struma.

Slides were submitted to Dr. Paul Klemperer, pathologist to Mt. Sinai Hospital, New York City, for an opinion and he reported that although a tuberculous process cannot be eliminated with entire certainty, he feels reasonably sure that we are dealing with a "Riedel's Struma."

The postoperative course was uneventful. She was discharged on the seventh postoperative day. Primary union had taken place. On discharge, there still remained an area of hardness at the site of each lobe. On October 24, 1939, examination of the neck revealed no evidence of previously noted indurations. The patient feels much improved and was discharged.

S. M., age forty-two, a white female housewife, was first seen January 14, 1941. Her chief complaint was goiter; duration two and one-half months. There was no history of chronic illnesses or goiter in the family, and the past history was irrelevant.

About two and one-half months before admission the patient noticed that her neck was becoming a "little stiff" following a history of throat infection. She had had difficulty in swallowing for a short time and still felt a sensation of tightness in her neck. At times, she felt somewhat dyspneic. She did not cough. She had noticed a hard swelling in her neck in the region of the thyroid gland. This swelling had not increased appreciably. At times, her voice was a little hoarse. There was no tremor. Sometimes, she felt irritable, but otherwise considered herself to be in good health. Her present weight was 135 pounds which was the most she had ever weighed.

Physical examination revealed a patient well nourished who appeared very complacent. The examination of the neck revealed a stony hardness in both lobes of the thyroid. The right lobe was a little larger than the left which measured 5 by 3 cm. The surface of the goiter was smooth and there was no fixation to surrounding structures. The whole gland moved easily on deglutition. There were no palpably enlarged glands. Examination of the vocal cords revealed a lagging of the right cord. The clinical diagnosis was chronic thyroiditis secondary to nasopharyngial infection, possibly Riedel's thyroiditis.

On January 15, 1941, the patient was operated upon under gas-oxygen anesthesia. The thyroid was exposed through a collar incision with separation of the ribbon muscles in the midline. The capsule of the thyroid was considerably thickened, greyish in color and smooth as though covered with an organized exudate. Early evidence of fixation was apparent. Keeping in mind the possibility that this might be Riedel's thyroiditis, a classical resection was not attempted. Rather, a resection was done which completely exposed the trachea as a decompressive procedure. There was little bleeding. The wound was closed in anatomical order, leaving a small amount of drainage material on each side of the trachea.

Pathological report: Macroscopic examination: Specimen consists of two portions of tissue measuring about 3 by 4 cm. On cross section, it cuts firmly. The cut surface is homogeneous in appearance and greyish in color.

Microscopic examination: Sections of the portions of the thyroid gland show a marked overgrowth of fibrous connective tissue dividing the thyroid into islands. Throughout, there is an infiltration of plasma cells and lymphocytes.

Tubercle-like areas with giant cells are noted. These, however, do not indicate the presence of tuberculosis. No evidence of malignant changes are seen in the sections examined.

Diagnosis: Thyroiditis, Reidel's Struma.

Dr. F. W. Stewart of the Memorial Hospital is also in complete agreement with this diagnosis.

Her postoperative course was uneventful. She was discharged on the seventh postoperative day. Primary union had taken place. The patient states that she no longer has sensation of tightness in her neck. Basal metabolism taken two weeks after discharge was −21.

Author	No. Thyroidectomies	Riedel	Percentage
Scholffer	450	1	0 20
Riedel	1,064	3	0 37
Berry	500	1	0 6
Schultz	305	3	0 98
Smith and Clute	1,200	5	0 41
Enderlen	3,396	1	0 03
Jackson	2,000	1	0 05
Eberts	1,015	1	0 10
Frazier	1,551	4	0 26
Pemberton	12,219	34	0 28
Joll	5,650	10	0 50
Eisen	2,908	7	0 24
Graham	17,826	27	0 15
Joyce	1,060	5	0 47

The etiology is obscure. The disease has a strong predilection for the female sex, about a three to one ratio. It occurs in 60 per cent of cases between the fourth and fifth decades. The youngest reported case was found in a girl of four years, the oldest case in a man seventy-eight years old. In 30 per cent of the cases, there is a history of a pre-existing goiter. Focal infection has been stressed as a cause. Bohan mentions the teeth; pharynx and tonsils were suggested by Monod, Searls, and Meeker. Lues, at one time, was thought a probable etiological factor by Monod, Delore and Alamartine, and Kuettner. However, in none of the cases reviewed could lues be established as a factor. Tuberculosis was also prominently mentioned as a cause by Schloffer, Crotti and Plummer. This theory has also been abandoned. Meeker men-

tioned the possibility of a relationship between remnants of the postbronchial body and Riedel's disease. Meyers considers Riedel's disease as a chronic granulomatous type of chronic inflammation. In one of his cases, he noted a histological picture of plasma cells and eosinophiles similar to that seen in Hodgkin's disease, except for the absence of Steinberg cells Ewing, Schultz and Meeker also support this theory. Williamson and Pierce classify Riedel's disease as a lymphadenomatous goiter.

Pathologically, one or both lobes of the thyroid may be involved entirely or partially. The gland is "stony" hard and in earlier stages, pale pink and limited to the normal confines with few adhesions to surrounding structures. The surface of the gland is smooth and cuts like cartilage. The capsule is thickened. The normal lobulation may be lost. As the disease progresses, the process may extend in extreme cases from the bifurcation of the trachea to the base of the skull, enveloping the blood vessels and ribbon muscles into one diffuse mass (Monod, Berry). The trachea, at first deviated, becomes later a flattened structure resembling a scabbard. With this compression of the trachea, paralysis of one laryngeal nerve is not unusual. The esophagus is rarely involved. Because this process is apparently not infiltrative in character, no invasion of neighboring structures is noted. The lymphatic glands are not involved. No involvement of the sympathetic chain has been reported. With the exception of cases reported by Monod and Berry, observations agree that the skin remains uninvolved in Riedel's thyroiditis.

Microscopically, the characteristic features are those of a chronic inflammatory process with extensive replacement of thyroid tissue by fibrous tissue which appears to be slowly strangulating the remaining islands of thyroid tissue. This picture apparently represents the terminal rather than the initial stage of the disease. In earlier stages, an infiltration consisting of lymphocytes, plasma cells, neutrophiles

and eosinophiles, appears in the intralobar tissue. The infiltration then perforates the capsule and spreads into the surrounding tissue. Gradually this inflammatory infiltration is replaced by extensive proliferations of connective tissue. The process in Riedel's disease is unilateral in about 40 per cent of the cases; the mass is seldom larger than a goose's egg with muscle tissue usually adherent to the gland. The cut surface is dull white with areas of colloid containing tissue. Microscopically, diffuse lymphocytic infiltration is absent. In the parenchyma, there are no traces of epithelium or colloid, except near the periphery. Beyond the fibrotic areas may be seen colloid containing vesicles in full activity. The fibrotic areas are composed of adult fibrous tissue with few cells and much hyalinization.

In 1912, Hashimoto described four cases which, though seemingly related to Riedel's disease, had so many different features that it was considered a new disease of the thyroid. At this point, it would be well to emphasize that Riedel, in his presentation, particularly mentioned the absence of functional disorders of the gland, either before or after the operation. Further, he made no mention of any lymphoid infiltration. Then Ewing, in 1922, following his studies of four cases, concluded that both Hashimoto and Riedel were describing different processes of the same disease, Hashimoto the early, and Riedel the final stages, respectively. Joll has recently reopened the controversy and is apparently justified.

Graham, Joll and McCollough believe that no relation exists between Riedel's and Hashimoto's disease for the following reasons: (1) Hashimoto's disease is confined to women over forty-five years of age. Riedel's disease may occur at any age. Men are afflicted as often as women. (2) Regardless of an operation, Hashimoto's disease tends to develop myxedema, frequently preoperatively. Riedel's disease, even after surgery, rarely leads to defective function. (3) Hashimoto's disease is diffuse from the onset; no part of the gland escapes. In Riedel's disease, localizations to part of a gland are not uncommon. (4) Widespread formation of delicate connective tissue is found resembling that in lymphadenoid goiter. In Riedel's disease, dense fibrosis resembling scar or keloid formation is found even in early stages.

Subsequent observations have apparently not substantiated all the above made statements. Shaw and Smith report one case of Riedel's thyroiditis associated with similar changes in the adrenal glands. Again, Perman and Wahlgren, in 1927, reported an operation for Riedel's disease in a chronic partly suppurating and necrosing thyroiditis. In 1929, Heyd reported a case, the specimen from which at the first operation, was reported as Hashimoto's disease. At re-operation thirteen months later for recurrence, the specimen suggested Riedel's disease because of a diminution of the number of lymphocytes and an increase in fibrosis.

CLINICAL PICTURE

Subjectively considered, the outstanding feature is dyspnea, occurring in 50 per cent of cases, a dyspnea out of all proportion to the increase in the size of the gland. Other pressure symptoms noted are dysphagia, dysphonia, a dry cough and in more advanced cases, stridor. In the early stages, the patient may be aware of thyroid enlargement for a relatively short time. Palpitation, nervousness, irritability, tremor, hyperhydrosis and loss of weight are relatively common. Pain, either localized to the neck or radiating to the ears, shoulder or chest, is often present. The average duration of these symptoms is about ten months.

The general health seems fairly good. With evidence of myxedema almost lacking, the thyroid, in early stages, may show a localized unilateral or a diffuse symmetrical enlargement which is always smooth. In 40 per cent of the cases, the enlargement is unilateral. In more advanced cases, the thyroid and surrounding structures are fused into a diffuse mass with complete

fixation of the thyroid. This mass may occupy the entire neck anteriorly. The cervical glands are not involved. Very significant also is the lack of involvement of the skin. The trachea is usually deviated and on laryngeal examination, paralysis of one vocal cord is not unusual. Although, Bohn, Waigate, Schultz and others report cases showing mild toxic symptoms with elevation of basal metabolism. This and other laboratory tests are not significant except for radiographic evidence of displacement and compression of the trachea.

DIFFERENTIAL DIAGNOSIS

1. *Malignancy.* (a) The great majority of the malignancies of the thyroid are grafted on previous adenomas and are in patients over forty-five years of age. (b) Rapid growth of the goiter without serious impairment of health favors Riedel's thyroiditis. (c) Skin and glands are involved in malignancy but not in Riedel's disease. (d) Pain is more frequent and severe in malignancy. (e) There are invariable voice changes in malignancy of the thyroid. Dysphagia, relatively minor in Riedel's thyroiditis, is an important symptom in malignancy. (f) The surface of the thyroid is nodular in malignancy, but smooth in Riedel's disease. Malignancy of the thyroid may be associated with disturbances of the circulation.

2. *Hashimoto's Disease.* There are: (a) Preponderance in women between forty-five to sixty years of age; (b) tendency to myxedema; (c) uniform enlargement of the gland lacking the stony hardness of Riedel's disease. (d) Pressure effects are seldom as severe as with Riedel's disease. (e) Riedel's disease shows a questionable response to radium. Hashimoto's disease responds quite promptly.

3. *Infectious Thyroiditis.* There is a history of a previous gastrointestinal infection. Hyperthyroidism is a prominent feature in thyroiditis. The consistency of the thyroid is not as hard as in Riedel's disease. There may be redness, tenderness and adherence of the overlying skin. The presence of pus, fever and leucocytosis favors infectious thyroiditis.

4. *Tuberculosis.* The thyroid may be enlarged and firm. It may rapidly infiltrate the surrounding tissues. The mass is hard and painful, occasionally breaking down to form a sinus. Adjoining lymph-nodes are involved. There usually is some evidence of tuberculosis in the tonsils, sublingual and parotid glands. Evening fever may be present. Some hyperthyroidism is also present. Other stigmata of tuberculosis are present.

5. *Lues.* Gumma is usually associated with enlargement of the gland. It occurs more often among women between the ages of twenty-five to forty-five. In about 50 per cent there is a previous history of goiter. Unlike in Riedel's disease, the skin is reddened and tender. The surface of the gland may be smooth or nodular and soft. The regional glands are enlarged. There is a tendency to suppurate. The Wassermann test will prove helpful.

6. *Phlegmon.* This usually occurs in men of middle age. There usually is a preceding infection (mouth, pharynx, salivary gland). The mass is very hard, covered by a red adherent skin. Death may result from laryngeal edema, pressure or exhaustion.

7. *Actinomycosis.* There is an early board-like hardness of the neck which later softens. A sinus then forms discharging yellow granules which are typical of the disease.

DIAGNOSIS

Before any treatment is begun, every attempt to make a correct diagnosis should be made. Malignancy of the thyroid and Hashimoto's disease will probably be the most difficult. The therapeutic effect of radium should prove most helpful because of the prompt response of Hashimoto's disease. The special characteristics of Riedel's disease should offer no special difficulty in distinguishing it from malignancy, provided that whenever malignancy

of the thyroid is suspected, Riedel's disease will also be considered.

TREATMENT

If an absolute diagnosis cannot be clinically established, it will then be advisable to perform a biopsy. Such a biopsy can be done without risk and is entirely justifiable. The first object of treatment in Riedel's disease is the relief of pressure. Success has been reported with radium by Renton, Charteris and Heggie and with x-ray therapy by Silatchek, Maloney and others. However, keeping the gross and microscopic picture of true Riedel's disease in mind, it seems improbable that these agents can exert any but the slightest effect. The treatment, therefore, remains essentially surgical. Radical surgery is not only unnecessary but dangerous. Attempts at extirpation of the diseased thyroid have been followed by a high mortality and the most serious of complications. When only a small wedge of tissue is removed, as for a biopsy, it has been repeatedly observed that the pathology will retrogress and in many instances, all induration of the neck will have disappeared within a few months. The first essential is to make a wedge resection just over the trachea so as to relieve the pressure. In most cases, this has been sufficient to give the patient relief and cure. Where radical attempts at removal were made, injury to the trachea, esophagus and great vessels have been reported, as well as injury to the recurrent nerves resulting in bilateral abductor paralysis. Tracheotomy has been necessary in the more advanced cases.

SUMMARY

Riedel's disease is comparatively rare, and in large series of thyroidectomies, its incidence remains fairly constant. Riedel's disease must be distinguished from Hashimoto's disease. The criteria for this differentiation have been given. Inasmuch as the prognosis and treatment are different in Riedel's disease, malignancy and Hashimoto's disease, a biopsy is advocated in doubtful cases. Not only is radical resection dangerous in Riedel's disease but it is distinctly contraindicated. Wedge resection over the trachea to relieve pressure is advocated. The future value of radium and x-ray therapy remains to be considered. A report is made of two cases of Riedel's disease.

CONCLUSIONS

1. Riedel's disease is comparatively rare.
2. Riedel's disease and Hashimoto's disease are distinct clinical entities.
3. The treatment is based upon an exact differential diagnosis, aided if necessary, by biopsy.

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EXSTROPHY OF RECTAL MUCOSA

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EXSTROPHY of the rectal mucosa is becoming a rarity. The condition merits discussion since its symptomatology is crippling and its surgical cure is often simple.

This syndrome usually is a late complication of the radical excision of hemorrhoids, especially if the choice of operation has been ill advised or its performance faulty. The operation described by Whitehead in 1882 was peculiarly susceptible to both of these errors in the hands of the relatively inexperienced. There can be no doubt that certain cases do merit some similar procedure but such cases are few and far between and demand special skill on the part of the operator. Unfortunately, neither of these facts was appreciated by the rank and file, although obvious to the expert. Hence, many patients were subjected to unnecessarily severe operative procedures which often resulted in crippling complications.

Whitehead[1] described the operation as follows:

"1. The patient, previously prepared for the operation and under the complete influence of an anesthetic, is placed on a high, narrow table in the lithotomy position, and maintained in this position either by a couple of assistants or by Clover's crutch.

"2. The sphincters are thoroughly paralyzed by digital stretching, so that they have 'no grip,' and permit the hemorrhoids and any prolapse there may be to descend without the slightest impediment.

"3. By the use of scissors and dissecting forceps, the mucous membrane is divided at its juncture with the skin round the entire circumference of the bowel, every irregularity of the skin being carefully followed.

"4. The external and the commencement of the internal sphincters are then exposed by a rapid dissection and the mucous membrane and attached hemorrhoids, thus separated from the submucous bed on which they rested, are pulled bodily down, any undivided points of resistance being snipped across, and the hemorrhoids brought below the margin of the skin.

"5. The mucous membrane above the hemorrhoids is now divided transversely in successive stages, and the free margin of the severed membrane above is attached, as soon as divided, to the free margin of the skin below by a suitable number of sutures. The complete ring of pile-bearing mucous membrane is thus removed.

"Bleeding vessels throughout the operation are twisted on division."

This differs from his original technic in that islands, or rather peninsulas, of mucous membrane, are no longer preserved and these anchors to windward are sorely missed.

The complications of this technic, even when properly performed, are failure of primary union, leading to stricture formation and destruction of the sensitive organs of the lower end of the rectum. This stricture is a particularly difficult one to deal with since it necessitates not only excision of the scar tissue but exact coaptation of the mucous membrane and skin at the precise point where nature intended the mucocutaneous junction to find itself. Failure to attain this difficult goal will give rise to one of two sad syndromes. These are similar to the complications resulting from poor technic in the performance of the Whitehead

operation and hence will be described with them.

Mr. Whitehead, in describing his technic,

FIG. 1. Exstrophy of rectal mucosa following an imperfect operation for hemorrhoids.

expressed himself poorly so that one who failed to study the paper might be misled upon two most important points, namely, the exact site of the first incision and the structures to be united with sutures. The exact site of the first incision should be into the mucous membrane just above the mucocutaneous junction since only in this manner can the cut borders of the caudad and cephalad mucous membrane be united. If the first incision be made through skin, then, barring a miracle, one of two complications will surely follow: Either the mucosa will be drawn down outside of the canal and exstrophy result or, more rarely, the skin will be drawn up into the canal.

Exstrophy of the mucous membrane may produce any or all of the following symptoms: a constant sensation of moisture about the parts, a burning sensation, a foul feculent odor, pains of darting, dragging, or neuritic nature. The latter are usually labelled neurotic, or worst of all, incontinence.

If the skin be drawn up into the canal, it will soon become moist, sodden and excoriated. Later a feculent discharge will be produced which will irritate, burn and sting until life is almost unbearable.

The simple operation of ligation and excision of hemorrhoids may result in similar pathology if too much skin is excised. This mistake is easily made if there are many skin tabs and the surgeon tries for too perfect a cosmetic effect. The exstrophic mucous membrane will then resemble a clover leaf. If only one of these is present, it is often mistaken for a fissure.

These accidents are preventable in the main. No one should attempt such a radical procedure unless it is certain that no other therapy will effect a cure and then only if the skill of the operator is unquestioned. For many years it has been the custom in many hospitals for most rectal operations to be turned over to the internes. This not only leads to bad surgery during their period of training, but launches them into private practice improperly trained and with little understanding of the anatomic and physiologic principles which should govern rectal surgery. It is appalling how many surgeons and even self-designated proctologists, are unfamiliar with the work of such men as Milligan, Morgan[2] and Levy[3] who have clarified the anatomy of the pelvic outlet. No one would dream of operating upon any other part of the body without first learning its anatomy, yet the rectum is assaulted daily by operators who have had no real surgical training.

The surgical cure of exstrophy of the rectal mucosa demands a plastic operation and elasticity negatives a rigid technic. The surgeon's own good judgment, as he proceeds with the operation, must be his guide. It is, however, very helpful to consider all possible methods before commencing to operate so that little time may be lost in pondering the most suitable method of meeting the immediate problem. We have found the following technic a simple one to alter when exigencies, encountered at operation, demand.

PROCEDURE

After adequate preoperative preparation, the patient is placed upon the operating

The free border of the bowel is grasped with forceps. The scar tissue is excised exposing a portion of the external sphinc-

Fig. 2. Incision through mucosa.
Fig. 3. Radial incisions.
Fig. 4. External sphincters partially exposed.
Fig. 5. Suturing mucosa.

table in the lithotomy position or the left Sims' position and the area is cleansed with 10 per cent tannic acid in alcohol. Anesthesia is attained through infiltration with $\frac{1}{2}$ per cent novocaine.

An incision is made through the mucous membrane just cephalad to its junction with the scar tissue and extending the whole circumference of the exstrophy.

ters. The redundant gut is excised and its free border is attached to its proper site with interrupted sutures. Radial incisions are made in the skin and their edges are trimmed in such a manner that the skin meets the mucous membrane and is maintained in position, without strain, by interrupted sutures. The following cases illustrate variations in this technic.

CASE REPORTS

CASE I. A boy, aged twelve, was born with an imperforate anus. A series of operations

FIG. 6.

FIG. 7.

Scar tissue
to be
excised

FIG. 8.

FIG. 9.

FIG. 6. Closing radial incision.
FIG. 7. Method of excising redundant mucosa.
FIG. 8. Scar tissue to be excised.
FIG. 9. Operation complete.

transfixed and ligated. The excess bowel was then excised. At 9 and 11 o'clock the structures were treated in the same manner. All bleeding

performed elsewhere had left him with an exstrophic perineal stoma and complete incontinence of feces.

Local anesthesia (novocaine ½ per cent) was administered. With the patient in the left Sims' position, the perianal area was infiltrated with ½ per cent novocaine solution. The exstrophic mucous membrane extending from 5 to 12 o'clock was dissected free above the mucocutaneous junction. The redundant bowel in the posterior line was delivered and a pedicle

points were clamped and tied. The wound was packed with gauze.

The boy gained almost complete control of his bowels and was allowed to go to camp and associate with other boys on an equal footing for the first time in his life. It is probable that a similar operation on the other side will give complete control.

CASE II. A woman, aged fifty-five, complained of a constant burning pain about the anus and occasional shooting pains into the

rectum. She had undergone four operations for hemorrhoids before consulting us. Exstrophy of the mucosa was present throughout the entire circumference of the bowel except from 8 to 9 and 3 to 4 o'clock at which two points there were peninsulas of skin extending up to the original mucocutaneous junction.

The operation consisted of the excision of the redundant mucosa at the level of the intermuscular septum and the control of bleeding. It was not considered necessary to suture the bowel in place since its position was maintained by the anchors left at the extremities of the transverse diameter. The wound was packed with gauze soaked in 10 per cent tannic acid in alcohol to encourage healing by granulation without scarring.

The patient states that she is much improved.

CASE III. A man, aged fifty-five, had undergone simple hemorrhoidectomy elsewhere. Apparently there had been many skin tabs and the surgeon had removed too much skin leaving a clover leaf exstrophy. The patient was complaining of a severe burning pain and pruritus ani.

Under ½ per cent novocaine anesthesia, the "clover leaves" were excised. The skin edges were freed and sutured together without tension. The wound was packed with gauze soaked in 10 per cent tannic acid in alcohol. The symptoms disappeared completely.

SUMMARY

1. Exstrophy of the rectal mucosa may produce crippling symptomatology.

2. It may be a late complication of the radical excision of hemorrhoids or even follow simple hemorrhoidectomy injudiciously performed.

3. Usually it may be avoided by a more careful selection of cases and a more thorough training for surgeons.

4. A plastic operation for its cure is described together with three variations in technic.

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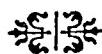
PREGNANCY AND DELIVERY WITH AN INTRAUTERINE PESSARY IN THE CERVIX*

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ALTHOUGH modern medical teaching credits intrauterine contraceptive appliances with only historical significance, their use is, unfortunately, still quite common, especially among those persons desiring a contraceptive device which relieves them of the "bother" associated with most present day methods.

The most commonly used of these is the gold plated "button" or "wish-bone" type of intrauterine stem. They are usually introduced after capping the pronged ends with a digestible capsule which permits easy introduction into the cervical canal and causes the spring to be subsequently released, thereby retaining the stem in the uterine cavity. It is usually left in place for months or years and is removed only for periodical cleansing. They do not commonly interfere with menstruation. Their apparent effectiveness is probably dependent upon the production of chronic endometritis, preventing nidation or bringing about an early abortion.

The literature is replete with articles pointing out the dangers attending the use of these devices.[1] They act as ladders for ascending infection into the uterine cavity, thus frequently causing salpingitis, endometritis and peritonitis. They call for the presence of a foreign body in the cervical canal and uterine cavity over long periods of time with consequent irritation, infection and possible carcinogenic action. They risk perforation of the uterus at the time of introduction. The intrauterine spring type frequently results in the imbedding of the prong within the uterine wall, and in a few cases, these have caused perforation of the uterus.[2] Extrauterine pregnancy, probably favored by the endometritis and salpingitis accompanying the irritating foreign body, has been reported.[3,4,5]

Although intrauterine gestations do occur, they usually result in early abortions.[6] The German literature contains two cases of pregnancy in the presence of an intrauterine stem pessary, one, a full term living child.[7,8]

A case of delivery of a seven-month living infant, in spite of the use of an intrauterine stem pessary, is reported here:

CASE REPORT

E. K., age thirty-seven, a white gravida VIII, para VII, was enrolled in the Out-patient Obstetrical Clinic of Greenpoint Hospital on January 23, 1941, and informed the examiner that her membranes had just ruptured. This fact was established by rectal examination and the patient was immediately admitted to the hospital.

In January, 1937, the patient had had a gold plated intra-uterine "wish-bone" type stem pessary introduced by a physician for contraceptive purposes. She was told that, although pregnancies might occur, they would quickly terminate in early, spontaneous miscarriages. When the pessary was removed a year later for cleansing, the patient promptly became pregnant and delivered a full-term infant in the breech position on October 28, 1939. This child died eight months later from measles complicated by meningitis. The pessary was then re-introduced in January, 1940. When the patient reported to her physician in July for removal and cleansing of the appliance, she was found to be about three weeks pregnant. Her last menstrual period was July 3, 1940. Attempts at removal of the pessary were unsuccessful and resulted in considerable bleeding which continued for two weeks. Because the patient did not want to lose the pregnancy she did not seek further medical care until coming to Greenpoint clinic at the time her membranes

FIG. 1. X-ray showing stem-pessary in the pelvis close to fetal skull.

FIG. 2. Photograph of infant shown holding the pessary which was imbedded in its scalp.

had ruptured. The antepartum course was otherwise uneventful. Fetal movements were noted three months prior to admission. There had been no edema, nausea, emesis, headaches, vertigo, dyspnea, constipation or vaginal bleeding.

The patient was married nineteen years. Her husband was living and well. She had had seven full-term pregnancies all spontaneous; two were breech deliveries. The largest baby was 12 pounds at birth. One child born in 1922 lived one month. The cause of death was undetermined. One spontaneous abortion of one month's gestation occurred in 1932.

On admission a purulent foul smelling watery discharge was seen coming from the vagina. Rectal examination revealed the cervix to be thick and from the os, which was dilated about 2 cm., a hard object protruded. This was a stem-pessary. The vertex was 3 cm. above the spines of the ischia and the fetal membranes were ruptured.

A flat plate x-ray of the abdomen revealed a seven-month fetus in vertex presentation with a stem-pessary visible in the pelvis in close apposition with the fetal skull. (Fig. 1.)

Labor pains began at 12 A.M. on January 25, just forty-eight hours after rupture of fetal membranes. At 6 P.M. the patient was spontaneously delivered of a well formed seven-month fetus, 36.3 cm. long, weighing 2 pounds 6 ounces. The *stem-pessary was imbedded in the fetal scalp* but was easily removed, leaving a noticeable but transient impression of the instrument. The infant was placed in a Davidson incubator and respirations of a weak, shallow character were soon established, although no cry was evidenced. The infant was apparently normal except for the depression in the scalp and a bluish discoloration of the right foot and fifth left digit. (Fig. 2)

The placenta was delivered intact spontaneously ten minutes after delivery of the child. Blood loss was 100 cc. Ergotrate, $\frac{1}{320}$ gr. was given intramuscularly to the mother and she was returned to the ward with a temperature of 101.2°F. and pulse of 120. The temperature had been constantly elevated during labor and it was believed that intragenital infection was the etiologic factor.

A daily prophylactic dose of sulfathiazole, gr. 12, four times a day, was given although no uterine culture had been taken, and the temperature gradually subsided to normal on the sixth day postpartum. Ethenyl estradiol, 5 gr., was given three times a day for three days to inhibit lactation. On the tenth day postpartum the patient was discharged to the out-patient department with a well involuted uterus, clear parametria and adnexae and good pelvic support.*

The mother was examined six weeks after delivery and was found to be in good general condition. The pelvis was found to be essentially that of a normal multipara.

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* The infant was discharged from the hospital sixty-seven days postpartum in good condition weighing six pounds three ounces.

PRIMARY OVARIAN PREGNANCY*

CASE REPORT

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IN 339 cases of ectopic pregnancy at St. Luke's Hospital in the past forty years, the following one is the only case of primary ovarian pregnancy, an incidence of 0.2 per cent.

CASE REPORT

The patient, A. B., was a thirty-eight-year old German woman who was separated from her husband and whose only previous pregnancy terminated in a miscarriage twenty years before. She gave a history of an attack of abdominal pain six years ago, diagnosed as "inflamed ovaries." Her menstrual periods had always been regular and normal and her last period was just two weeks previous to the onset of her symptoms with no bleeding since then. She was admitted to St. Luke's Hospital on September 30, 1939, six hours after the onset of sudden severe crampy generalized abdominal pain, which awakened her at 6 a.m. From the onset of the pain, which persisted without change, she was unable to lie down without marked increase in the pain and faintness.

On examination she was pale, apprehensive and obviously acutely ill. She sat up in bed somewhat bent over forward holding her abdomen and was absolutely unable to lie down. Her abdomen, examined in this posture was slightly protuberant and doughy and showed only moderate tenderness, mostly in the left lower quadrant, and marked rebound tenderness but practically no spasm. By pelvic examination there was marked tenderness in both fornices with a sense of fullness on the left. It was believed that her inability to lie down was due to a shift of intra-abdominal blood into the subdiaphragmatic region on attempting this change of position.

She had a normal temperature, a pulse of 100, and a blood pressure of 82/48. Her blood count was 63 per cent hemoglobin, 3,600,000 red cells, and 23,900 white cells, with 92 per cent polymorphonuclears, and her Wassermann test was negative.

Because of the menstrual history she was
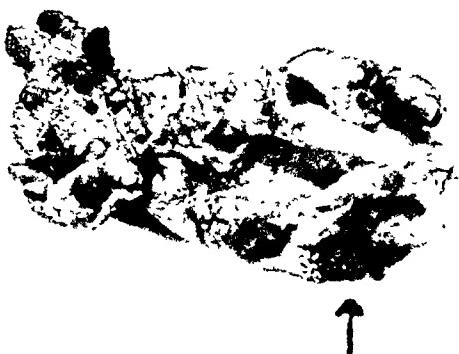
Fig. 1. Photograph of gross specimen. Sections have been cut from the tube, ovary and pregnancy. The tube lies above with the ovary beneath it. Arrow points to the pregnancy, which is about 1 cm. in diameter.

thought to have a ruptured Graafian follicle with rather severe bleeding.

At operation a large amount of clotted and fluid blood was found filling the peritoneal cavity. The right tube and ovary and the uterus were normal. The left tube and ovary were attached to the back of the broad ligament by filmy adhesions. The tube was apparently normal and the ovary was somewhat enlarged and contained on its lateral surface an open follicle about 1 cm. in diameter which was bleeding actively. A left salpingo-oophorectomy was done and a 500 cc. indirect blood transfusion given.

The postoperative course was uneventful and she was discharged on the thirteenth day. There was no vaginal bleeding during her hospital stay.

Microscopic sections showed the ovary to be involved in a hemorrhagic process with much

interstitial hemorrhage but with portions of the ovary remaining almost intact. There were chorionic villi near the surface, embedded in

follicle, the ovum remains behind and is fertilized and develops in situ.[1,2] The other view is that the ovum escapes from the
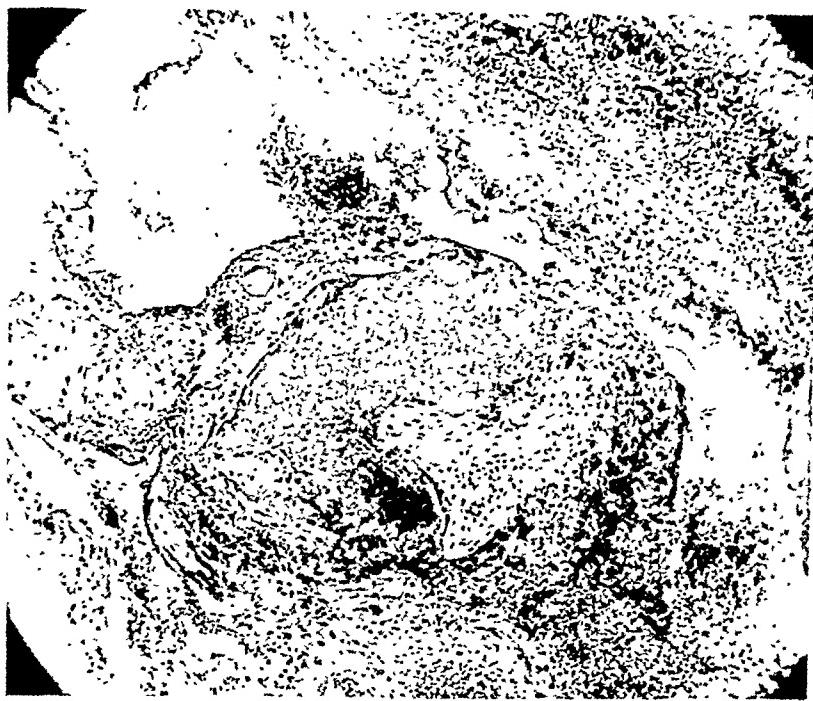
FIG. 2. Microphotograph showing chorionic villi.

fibrinous blood clots. In a few areas there were syncytial cells and a marked decidual reaction. The tube was edematous but otherwise normal. The pathologist, Dr. Leila C. Knox, said, "Since there is undoubtedly a pregnancy, it must be considered of the ovarian type, and is situated entirely outside the tube."

Some of the reported cases do not meet all the requirements laid down by Spiegelberg in 1878 and later augmented by Williams and Norris.[1,2,3] These are: (1) The tube on the affected side must be intact and microscopically free from any evidence of gestation. (2) The fetal sac must occupy the position of the ovary. (3) The mass must be connected with the uterus by the utero-ovarian ligament. (4) Definite ovarian tissue must be found in the sac wall and be present in several portions of the wall at some distance from one another. This case easily meets all of these criteria.

There are two theories of ovarian pregnancy. One, that on rupture of the Graafian

ruptured follicle, is fertilized and for some reason does not move into the tube but implants in the ovary, either in the original Graafian . follicle or elsewhere. The latter theory is probably the correct one. If it develops in the follicle, the trophoblast destroys the corpus luteum which forms, and the lutein cells make up some of the decidua. In some of the reported cases a corpus luteum was present in the ovary outside the pregnancy.[4] In this case there was none. Question has been raised as to whether any true decidua forms in the ovary.[1,2,5] There seems to have been one in this case.

The duration of the pregnancy is usually longer in the ovarian than in the tubal type[1,2] because of the elasticity and resiliency of the ovary, and cases have been reported which went on to full term or to lithopedia.[1,6] This case is unusual in the short duration and early rupture of the pregnancy, evidently not over two weeks, since the patient had an evidently normal

menstrual period just two weeks before the onset of her symptoms and operation.

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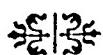
PROLONGED pressure congestion or disease in and about the damaged joint, involving ligaments, tendons, nerves, and fasciae, draws all the moving parts into the scar and tends to bind the involved tissues and structures permanently together, usually in malposition.

From—"Wounds and Fractures"—by Orr (Charles C. Thomas).

STERILIZATION OF THE OVARIES BY ROENTGEN RAYS IN THE TREATMENT OF DISTANT METASTASES FROM PRIMARY CARCINOMA OF THE BREAST*

REPORT OF TWO CASES

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PRIMARY carcinoma of the breast as well as its bone and lung metastases in women sometimes recede following castration.[1-4] The mechanism of the effect is not exactly known although there seems to be little doubt that the withdrawal of the hormones is responsible to a large extent. This assumption becomes especially convincing if sterilization is brought about by roentgen rays and the secondary deposits are so far remote from the pelvic fields of irradiation that a direct effect on the metastatic lesions is hardly probable. For that reason we are reporting two illustrative cases, one with widespread bone and early lung involvement and one with bilateral lung metastases.

CASE REPORTS

CASE I. Mrs. M. B., thirty-nine years old, was admitted to the State of Wisconsin General Hospital on August 12, 1939, complaining of stiffness and pain in the joints and also of persistent cough. Two years ago she had the left breast removed for carcinoma; one month ago a recurrent nodule was excised from the left axilla. X-ray examination revealed metastatic carcinoma in the right first, third and fourth ribs, in the inferior lateral aspect of the left scapula, in the eleventh thoracic and third lumbar vertebrae, in the pelvis, the right femur and also pulmonary metastases to the bases of both lungs. On August 16, 17, 18 and 19 she received 200 r in air with customary deep therapy technic (HVL in Cu .85 mm.) over the anterior and posterior pelvis to produce sterilization. On re-examination in October, 1939, she had experienced "remarkable" relief from pain, her menstruation had stopped, but there was some advance in the destructive lesions seen before. Local x-ray therapy was applied to the neck of the right femur to guard against pathologic fracture. She remained free from pain until April, 1940. X-ray examination showed well marked recalcification of all bone lesions; the only evidence of a new metastasis was a healing fracture in the left sixth rib. The lung lesion had also receded. Special attention is drawn to the reconstruction of the tip of the left scapula which was found almost entirely destroyed on first admission. (Figs. 1a and b.) She complained of discomfort in the right lower abdomen; a hard mass about 4 cm. in diameter could be felt there. X-ray therapy was given over that region. Several metastatic skin nodules under the right breast were removed for psychic reasons only; microscopic examination showed adenocarcinoma. Since then new lesions have developed in the pelvis, left femur and the left sixth rib. Local x-ray therapy was administered to the left hip and femur to relieve pain. On last admission in January, 1941, new foci in the thoracic spine and the right humerus had appeared. The latter was irradiated because of pain. She complained of several attacks of nausea which occurred before x-ray therapy had been started. The lesion in the left scapula remained calcified and the lung parenchyma was clear.

CASE II. Mrs. L. K., forty-seven years old, was admitted to the State of Wisconsin General Hospital on May 26, 1937, with the chief complaint of a lump in her left breast. She stated

that she had noticed the lump about four years ago and at that time it was the size of a hazelnut. She had never had any pain in the left

struating, although there were indications of beginning climacteric—she had missed several periods and those that did occur were accom-

a   b

Fig. 1. a, Roentgenogram taken in August, 1939, before sterilization. Note destruction of tip of left scapula. b, Roentgenogram taken in April, 1940. Note recalcification of defect shown in Figure 1 a. (No local treatment given.)

breast until one week before admission. This was accompanied by a continuous itching. There has never been any discharge from the nipple. She consulted her family physician first on May 22, 1937, who referred her to this hospital for treatment. On examination the left breast was larger than the right and a mass about the size of a large egg could be felt in the upper, inner and outer quadrants. The skin was attached to the mass but the latter was not attached to the underlying muscle. It was stony hard and nodular. Several enlarged glands were palpable in the left axilla; they were fixed, hard and not tender. X-ray examination of the chest revealed bilateral metastases, especially in both bases, and a bone lesion was present in the wing of the left sacrum. In view of these findings a simple mastectomy plus excision of as many axillary nodes as possible was done. Histologically, the tumor was classified as duct carcinoma. Since the patient was still men-

panied by metrorrhagia—castration by roentgen rays seemed advisable and was carried out on June 7 to 11 with the same technic as described in Case 1. The patient was seen at regular intervals; in November, 1937, the lung lesions had disappeared. The patient remained well for almost two years; (Figs. 2 a and 2 b) in May, 1939 she developed glandular metastases in the left cervical region; following surgical removal local x-ray therapy was given. On re-examination in October, 1939, extensive lung metastases were found, also lesions in the right hilum. When last seen in April, 1940, the presence of widespread metastases in both lungs and skeleton rendered further x-ray therapy futile.

COMMENT

In the first case sterilization resulted in calcification of nearly all bone lesions and

clearing up of the metastatic spread in both lung bases. While one may rightfully question the indirect effect of the with-

lasting two years was remarkable and this observation confirmed by others constitutes a definite indication for steriliza-
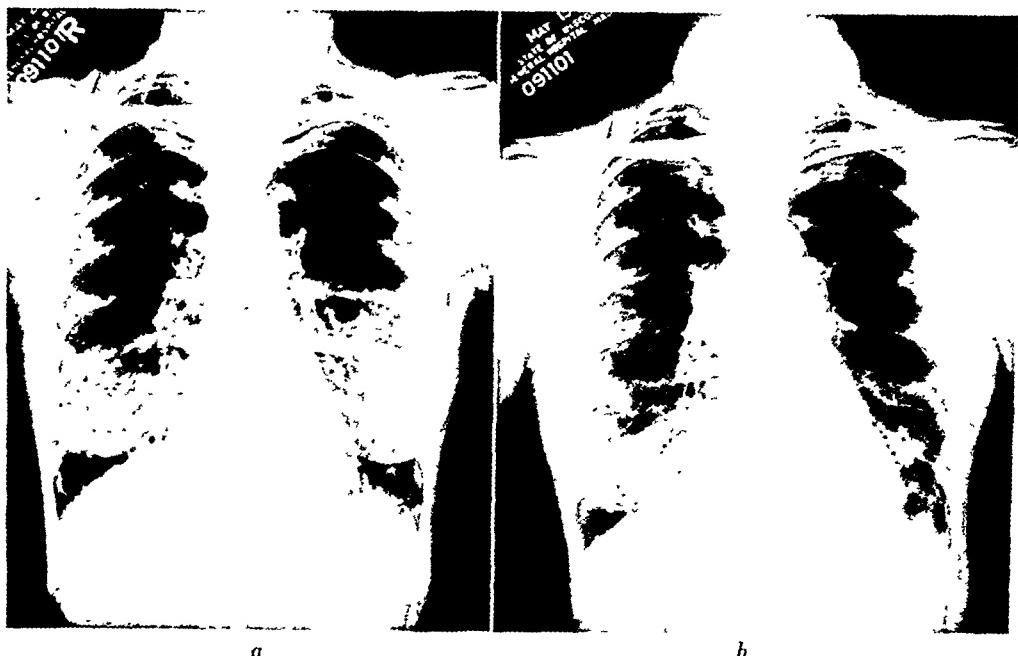
FIG. 2. a, Roentgenogram of the chest taken in May, 1937, showing bilateral metastases in the lung bases. b, Roentgenogram of the chest taken in May, 1939; no evidence of metastases in the lung bases. (No local treatment given to either lung.)

drawal of the hormones as far as the metastatic foci in the pelvic bones are concerned, as they were partly in the field of irradiation, it does not seem plausible to use this argument in explaining the response of the lesions in the upper ribs, the scapula and in the lungs. As far as the symptomatic relief is concerned, it should be mentioned that on several occasions the medical consultant recorded on the history the "euphoria" of the patient which was in sharp contrast to the physical findings and spoke well for the palliative effect of sterilization alone without local irradiation.

In the second case the disappearance of the lung lesions as demonstrated in the roentgenograms and which took place without any direct exposure of the lungs can hardly be explained by any other mechanism than some endocrine reaction occurring in connection with the inactivation of the ovaries. The period of palliation

tion in patients of this type. As to the age factor we believe that even in women below forty years castration is indicated if widespread skeletal or bilateral lung metastases are present. It seems to offer at least a chance of palliation and prolongation of useful life and this should well outbalance the discomfort due to the menopausal symptoms.

SUMMARY

1. The effect of sterilization of the ovaries on metastatic carcinoma from a primary focus in the breast is briefly discussed.

2. Two illustrative cases, demonstrating the efficacy of this procedure, are reported.

3. Roentgen sterilization of all women, regardless of age, who have metastatic carcinoma from a primary carcinoma of the breast and of all women of forty

years or older as a prophylactic measure is recommended.

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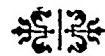
Those postoperative wound and stitch abscesses (in operative treatment of fractures) which do occur are often made worse by surgical and dressing interference; the danger of dressing is usually greater than that of letting the patients alone, well immobilized and with wounds protected.
From—"Wounds and Fractures"—by Orr (Charles C. Thomas).

ILIOCOLIC INTUSSUSCEPTION*

DIAGNOSIS BY X-RAY WITHOUT CONTRAST MEDIA

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THE diagnosis of intussusception of the bowel by means of an x-ray examination is a well known and long established procedure. Snow,[1] in 1913, was the first to report a case in which he confirmed a diagnosis of intussusception by use of a barium enema. In the same year appeared an article by Ladd,[2] in the following year one by Lehmann[3] and Groedel.[4] For an x-ray diagnosis a barium enema is advocated by the numerous authors, although some have been diagnosed by following the progress of the meal given by mouth. The appearance of the bowel, when the barium reaches the intussuscepted loop, has been well described and the types of intussusception have been classified.

Among the many papers on this subject are those by Sussman,[5] who reported four cases and gave an excellent summary of the types and causes, emphasizing the importance of studying the colon following defecation after barium enema, Shatzki[6] who added eleven cases to the accumulated literature and also analyzed the roentgen signs, and Kirsner and Miller[7] who emphasized the value of the postevacuation film and reviewed the entire subject.

It is not the purpose of this paper to review the causes, types or criteria for diagnosis of intussuception. The reader is referred to the articles by the above mentioned authors and in addition to those of Wasch and Epstein,[8] Davis and Parker,[9] Ashbury,[10] Ochsner and Gatch.[11] All the above agree that a barium enema is an invaluable aid in diagnosis and describe the x-ray signs as an obstruction to the barium entering the colon with a filling defect. The head of the barium forms a cap and corresponds to the head of the intussusception; or, the barium may enter the sheath (intussuscepiens) surrounding the intussuscepted gut and a distended loop of bowel will be seen. The barium may trinkle through the intusscepted loop (intussusception) and show a string-like appearance which will be surrounded by the distended intussuscepiens. Barium has been used by the above authors either by enema or by mouth in establishing the x-ray diagnosis.

Most clinicians object to the use of barium by mouth in face of an intussusception with the possible mechanical obstruction. Some hesitate to use a barium enema. The purpose of writing this paper is to present two cases of ileocolic intussusception which were diagnosed on the flat film without the use of barium and to suggest that flat films be taken more often on suspected cases of intussusception.

It has been a popular procedure by members of the staff of the Mount Zion Hospital to refer most cases of suspected acute abdominal conditions for a flat plate of the abdomen (Brunn and Levitin).[12] Intussusception in children is not as common in our hospital as reported by other writers. We certainly cannot compare our few cases to the series of 400 cases reported by Koch and Oerum[12] and 100 reported by Hipsley.[14]

We are not original in taking a flat film for a suspected intussusception. Davis and Parker[9] mention that a flat roentgenogram was taken on one of their cases, but not sufficient evidence was there for a diagnosis and a barium enema was necessary. Shatzki[6] states that few facts have been published in regard to examination without contrast media and,
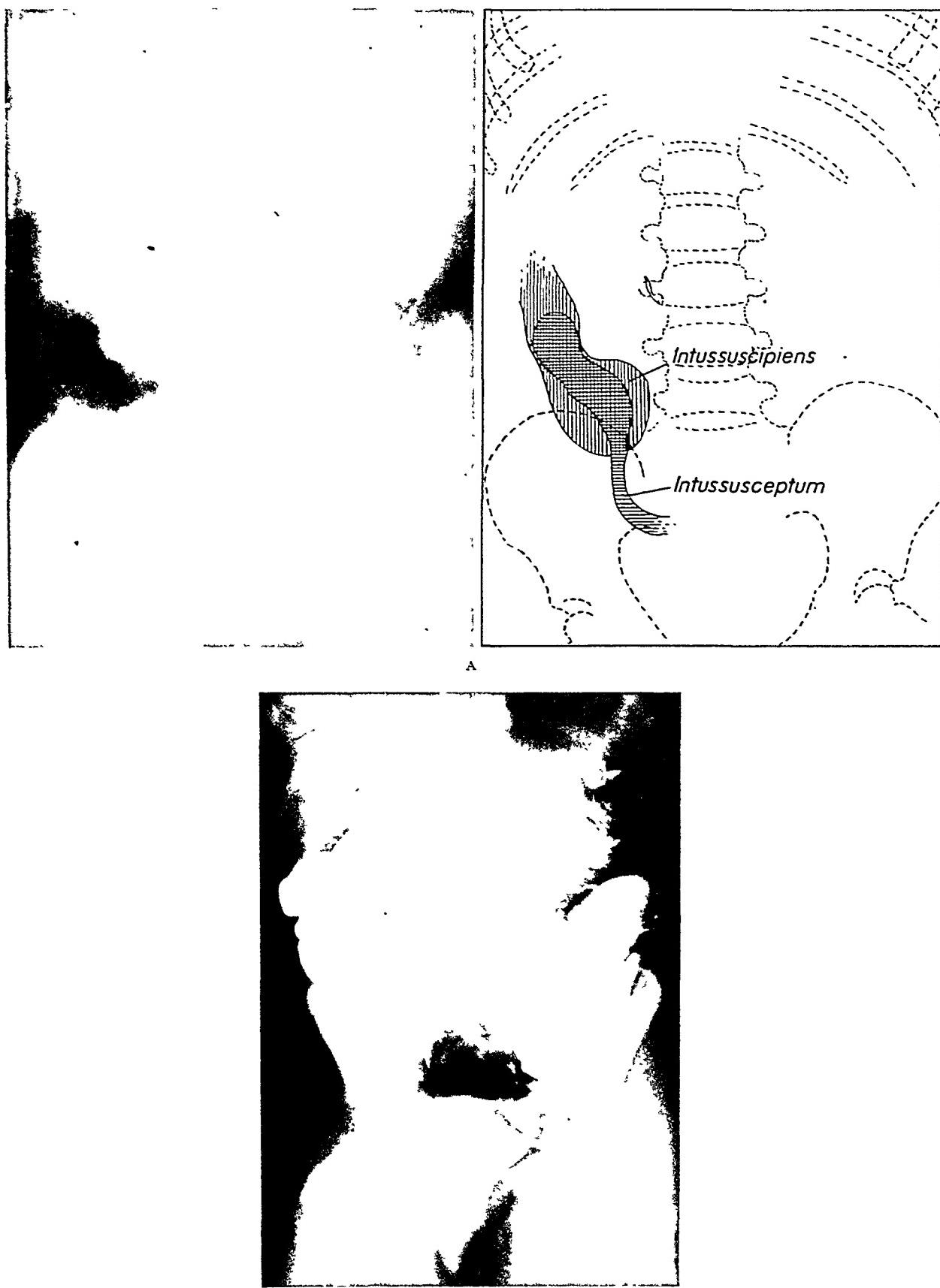
Fig. 1. A, ileocolic intussusception; B, intussusception reduced by barium enema.

A

B
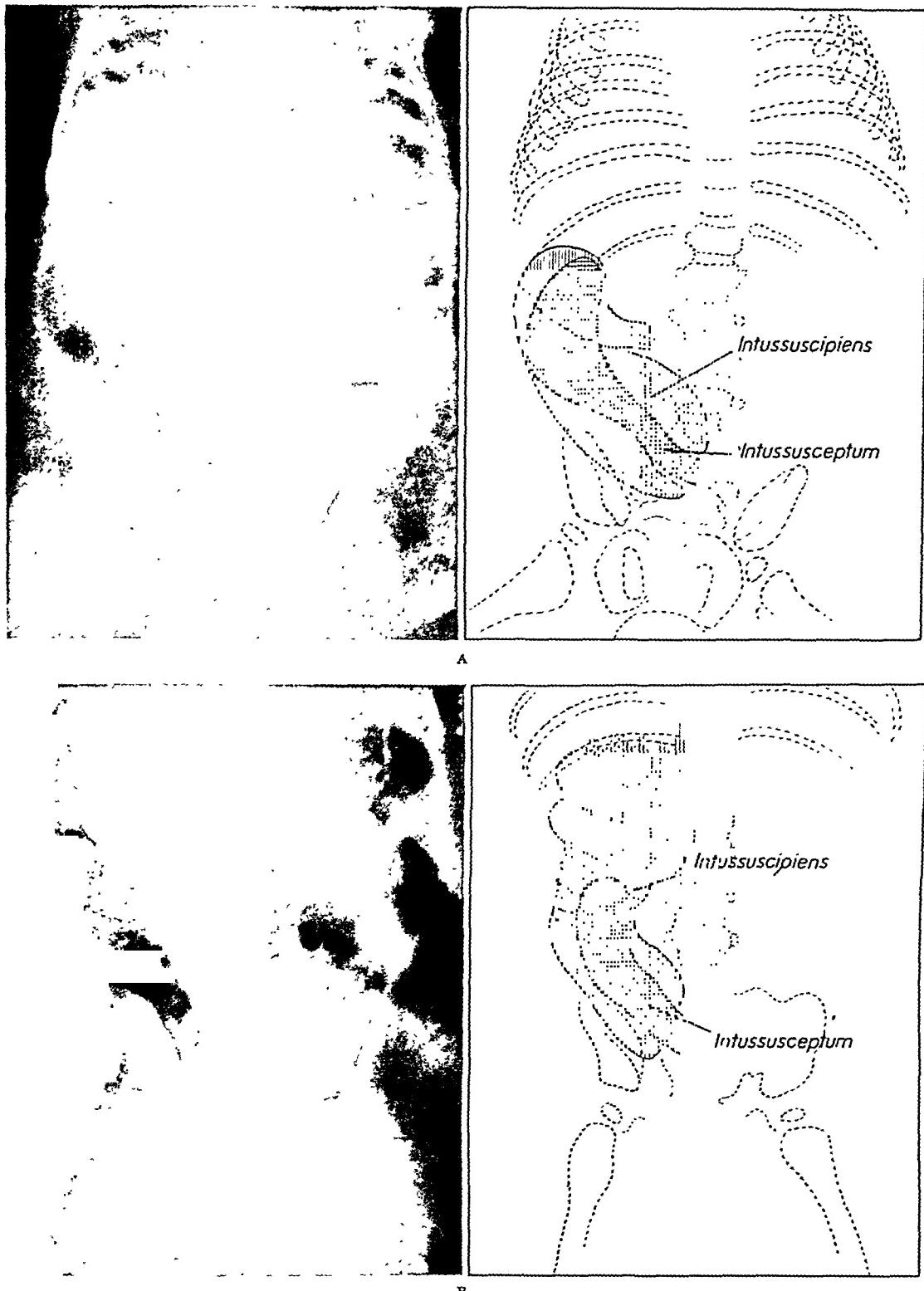
FIG. 2. A, ileocolic intussusception with small bowel dilatation; B, unsuccessful reduction of the intussusception. The barium has reached the top of the intussusception. The intussuscepiens has dilated at this point but the pressure of the barium is unable to disinvaginate the bowel.

although he had no cases to publish of his own, he proceeds to give the findings of an intussusception on the flat plate as: (1) Absence of a normal pattern of air in the cecum and ascending colon; (2) the area of intussusception has a sausage-shaped homogeneous shadow representing the intussuscepted portion of the intestine; (3) there may be air rings in the distended bowel surrounding the central shadow (intussuscepted gut); (4) if the central canal contains air, there will be a narrow air-filled lumen surrounded by a thick soft tissue cylinder.

Kloiber[15] emphasized the importance of finding a small bowel dilated with fluid, indicating evidence of a mechanical obstruction, but this does not necessarily imply an intussusception as the underlying cause.

In the two cases reported in this paper the findings were so typical that we wonder if they are not present more often but have been overlooked by not first taking the flat film. Both cases showed two loops of gas in the right lower quadrant, one within the other. The dilated intussuscepiens were readily recognized as cecum. Within this dilated loop was the second loop narrowed at its lower end, i.e., the neck of the intussusception. One case also had a dilated small bowel as the result of the mechanical obstruction produced by the intussusception. In both cases it was decided to try reduction by enema and as we wished to see if it was successful, a barium enema was given under fluoroscopic control.

The reduction of the intussuscepiens by enema antedated the x-ray diagnosis. The largest series reported was from Denmark by Koch and Oerum[13] in 1912. Four hundred cases were reported, all treated by enema. The patients were under anesthesia which allowed for more relaxation and made it possible for the surgeon to massage against the direction of the intussusception. They reported only fifteen failures to disinvaginate out of the 400

cases. This procedure was first suggested by Hirschprung.[16] Hipsley,[14] in 1925, analyzed 100 cases in which sixty-two cases were completely reduced by enema with a mortality of 5 per cent. This is in contrast to a surgical mortality of 6.6 per cent reported by Wilfred Vickers.[17] Since then successful reductions of intussusception under fluoroscopic control have been reported by Retan[18] and Stephens.[19] In our two cases we were successful in reducing one. The other case in which the symptoms had been present for five days had to go to surgery. Both patients have since been well.

CASE I. L. C., a male age three years, was a healthy child with no unusual history until three A.M. when out of a sleep he was seized with a sharp pain, doubling him up. The pain seemed to occur every ten minutes for a duration of about one minute. During the intervals he was free of pain and comfortable. One hour later he had a loose bowel movement. No gross blood was seen. At 8:00 A.M. he vomited. The patient had an x-ray examination at 10:00 A.M. (seven hours after onset) on entering the hospital. The white blood count at entry was 11,000 with 52 per cent P.M.N. X-ray examination (Fig. 1 A) showed a distended loop of gas in the right lower quadrant corresponding to the cecum, within this loop was a second distended loop, narrowed at the entrance into the cecum. An x-ray diagnosis was made of an ileocolic intussusception. A barium enema was given to see if the intussusception could be reduced under fluoroscopic control. The barium entered slowly without difficulty until it reached the head of the intussuscepted loop of bowel. There was a delay with further dilatation of the ascending colon (intussuscepiens). At this point the child complained of considerable pain. Following this there was a sudden release of the barium into the cecum and an overflow into the terminal ileum. The intussusception was reduced. (Fig. 1, B.) The child has remained well. With the expulsion of the enema there was some blood; this being the first time blood was found in the stool.

CASE II. An infant girl six months old, with nothing unusual in her past history until three days prior to entry had intestinal colic. On the day of entry the child had considerable pain

and there was a palpable mass in the right lower quadrant White blood count was 7,900 P.M.N. 22 per cent. An x-ray of the abdomen showed a distended loop of bowel in the right lower quadrant within which was a smaller loop of bowel with a narrowed neck. The remaining small bowel was distended with gas. (Fig. 2 A.) The case was diagnosed as an ileocolic intussusception with a small bowel mechanical obstruction. Although Retan[18] believes that a successful reduction by barium enema must take place in the first twelve hours and this patient had already gone four days, nevertheless, a barium enema was given under fluoroscopic control. The fluid entered without difficulty until it reached the head of the intussusceptum. (Fig. 2 B.) At this point, however, the child had considerable discomfort and expelled the enema and tube. The attempt to reduce the intussusception having proved unsuccessful the child was taken to surgery. On opening the abdomen the diagnosis of ileocolic intussusception with small bowel obstruction was confirmed. The intussusception was carefully reduced and the child made an uneventful recovery.

CONCLUSIONS

1. A flat film of the abdomen may give necessary diagnostic clue to a diagnosis of ileocolic intussusception.

2. The findings consist of a gas distended loop within which may be found a smaller loop with a narrowed neck.

3. Reduction of the intussusception by barium enema may be successful if done early.*

* Since this paper was written an article on the same subject has appeared by Abrams, Hyman S. Intussusception. Particular reference to roentgen diagnosis without opaque media. *Radiology*, 36: 490–492, 1941.

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MENTAL DISORDERS ASSOCIATED WITH HYPERTHYROIDISM

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PSYCHOSIS is not a common complication of hyperthyroidism. Johnson reported only twenty-four instances of psychosis in 2,000 patients with hyperthyroidism. Foss and Jackson studied 800 patients with hyperthyroidism and found evidence of mental disorder in two cases. Conversely, a goiter was present in fifty of 1,700 psychotic patients studied. Parker states that less than 2 per cent of patients with exophthalmic goiter present evidence of mental derangement. In view of the rather infrequent association of these two conditions and because of the unusual results obtained, we felt justified in presenting our case and discussing the nature and relationship of this association in general.

A variance of opinion has been expressed regarding the rôle of the thyroid as an etiological factor in the production of psychosis. Hammes believes that psychoses encountered with thyrotoxicosis can be classified with, and have the usual characteristics of, ordinary psychoses. He considers the hyperthyroidism an associated rather than etiologic condition. On the other hand, Walker considers the thyrotoxicosis as etiological. Katzenelbogen and Luton believed that the thyroid dysfunction was a precipitating or aggravating factor in their cases.

Thyroid malfunction is accompanied by deviations from the average normal mental and motor activity; as for example, retardation is a concomittant of myxedema and cretinism, and mental and motor over-activity with hyperthyroidism. If this is true, one would expect some possible etiologic relationship between thyroid disease and psychoses in certain cases. Hyperthyroidism, however, has not been associated with any one type of psychosis. In Jameson and Wall's series each case exhibited a different psychological response and psychotic manifestation. They believed that given a favorable background, including familial and personality propensities, and such factors as prolonged physical and emotional stress that a latent thyroid disease might be precipitated with an associated psychosis of any type.

Dunlap and Moersch classified their cases according to the psychic manifestations and the thyroid pathological condition present. The predominant types of mental reactions were (1) toxic exhaustion, (2) acute delirium, and (3) manic-depressive psychosis, 91 per cent of the series being made up of the first two groups.

Toxic exhaustive psychoses were present only in cases of thyrotoxicosis, due to either exophthalmic or adenomatous goiter. The majority gave a relatively short history of mental disturbance and under medical care showed marked and rapid improvement. Acute delirium, likewise, was seen only in association with hyperthyroid states. The terms acute delirium, thyroid crisis, hyperthyroid reaction and thyroid storm are used to designate more or less the same condition. These cases are regarded as presenting the one possible definite relationship between hyperthyroidism and mental disturbances, for no instance of familial history of psychosis or of a previous mental disturbance occurred in this group.

All these patients presented a severe degree of hyperthyroidism, but the severity of the hyperthyroidism was found to be no index to the severity of the mental reaction.

Typical acute delirium, or thyroid crisis, is seen infrequently since the introduction of compound solution of iodine in the treatment of thyrotoxicosis. When it occurs, however, the psychosis is in proportion to the severity of the hyperthyroid reaction and disappears when the crisis is controlled.

The manic-depressive cases made up the third most common group in Dunlap and Moersch's series. Since this psychosis is found complicating cases of goiter without hyperfunction, as well as those with thyrotoxicosis, the hyperthyroidism cannot be considered responsible for the development of the manic-depressive reaction. We have seen an interesting case of hyperthyroidism which was complicated by the development of a mental disorder.

CASE REPORT

A fifty-one year old white, married woman was admitted to the hospital with a chief complaint of nervousness and increasing weakness of one year's duration. One year prior to admission, because of increasing asthenia, nervousness, irritability, tremor, crying spells, increased appetite and diaphoresis, the patient consulted her physician. Two months prior to her admission she developed edema of the ankles, dyspnea on moderate exertion, orthopnea and a nonproductive cough. Ten days before admission she was told that her heart was "beating 200 beats too fast" and was confined to bed. She had lost eighty pounds in weight during the last three years.

Her past history was essentially negative. Physical examination revealed an undernourished woman who was alert, co-operative but very apprehensive and nervous. The blood pressure was 165 mm. of mercury systolic, and 85 mm. of mercury diastolic. The pulse rate was 136 beats per minute and respiration 28 per minute. Moderate exophthalmous and slight lid lag were present. The thyroid was diffusely enlarged to a size approximately six to eight times normal. A bruit was present over both lobes. The heart was enlarged to the left and a faint apical systolic murmur was present. There was pitting edema of the ankles and muscular strength of the extremities was poor. A marked tremor of the hands was present.

Urinalysis showed a moderate amount of albumin. The concentration of nonprotein nitrogen was within normal limits and the blood cholesterol 118 mg. per cent. Hemoglobin was 72 per cent, leukocyte count 5,200, and erythrocyte count 4,710,000 per cubic millimeter of blood. The serologic reaction for syphilis was negative. Basal metabolic rate was plus 69 per cent.

Roentgenographic examination of the chest showed a widening of the aortic arch and slight cardiac enlargement. An electrocardiogram revealed nothing unusual.

The patient responded poorly to the usual methods of preoperative preparation and for this reason was given two treatments with x-ray at five week intervals. She showed some improvement, and on her fifty-third hospital day, three weeks following the first x-ray treatment, the basal metabolism rate was plus 40 per cent and she had gained five pounds. Despite the general improvement, surgery was delayed because of the presence of an acute follicular tonsillitis.

During the hospital stay the patient's mental status showed gradual deterioration, so that by the sixty-sixth day doubt was expressed as to the advisability of, or benefit to be expected from, thyroidectomy. She was disoriented as to time, place, and person, and showed in general marked motor depression. She wept when spoken to and could not remember her visitors from day to day. She exhibited occasional delusions and hallucinations, hearing or seeing people outside her room who had come to kill her or to take her to the operating room. For transient periods her orientation and general mental reaction seemed improved. These episodes were usually associated with some improvement in the general toxic status as indicated by lowering and steadying of her pulse and temperature levels.

We assumed care of this patient on her seventy-ninth hospital day and after consultation with her previous physicians decided that a more radical program must be instituted. Consequently, after two weeks of vigorous preparation, thyroidectomy was performed. Pathological examination confirmed the clinical diagnosis of exophthalmic goiter. The patient made an uncomplicated convalescence and by

the fifth postoperative day was walking about, was well oriented and conversed rationally. She was dismissed from the hospital ten days following the operation.

Three months following the operation the patient had gained thirty pounds, was doing her own housework and manifested no evidence of mental disturbance. Nine months following operation she had gained fifty pounds and was in the best of health.

COMMENT

We believe that this patient had marked hyperthyroidism due to an exophthalmic goiter and in addition developed a toxic exhaustive type of psychosis. The increase in the toxic and psychotic symptoms, in spite of adequate medical care, was unusual. It is possible that the tonsillitis and the consequent foci of infection aggravated this condition. The most unusual feature presented by this case is the fact that the psychosis of this severity cleared following thyroidectomy. It was our opinion, and this was substantiated by discussion with Pemberton, that it is very unusual for such a patient to be materially improved from the mental viewpoint following control of the hyperthyroidism. On the other hand, occasionally the psychotic symptoms of a shorter duration, and usually those associated with a crisis of the disease, disappear with control of the thyroid hyperfunction. Certainly one should not consider the presence of a mental condition a definite contraindication to surgery, and in selected cases indicated surgery is advised.

SUMMARY

Hyperthyroidism is not specifically associated with one type of psychosis. Toxic exhaustive reactions and acute delirium are probably the most common mental disturbances complicating thyroid hyperfunction. The content of the psychoses does not differ essentially from that of similar types of psychoses in individuals without hyperthyroidism. When a psychosis occurs in the presence of hyperthyroidism it should not be considered a definite contraindication to surgery. The prognosis of the psychosis probably depends upon the ratio of thyroid toxicity to the underlying mental instability of the patient.

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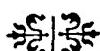
PERITONEOSCOPY VERSUS EXPLORATORY LAPAROTOMY

A COMPARISON OF MORBIDITY AND MORTALITY

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THERE still appears to be great divergence of opinion in the profession with regard to the value of peritoneoscopy as a diagnostic procedure. It has not as yet been accorded that measure of general popularity which it deserves, as a safe and effective method of surgical investigation in selected cases. Perhaps this is largely the fault of its advocates, who publicize its simplicity of technic but often omit detailed statistics of end results from which alone its value can fairly be judged.

It is a well established surgical principle that the advantages claimed for any new procedure must be considered in relation to the operative morbidity and mortality associated with it. This is of deep concern not only to the doctor and the hospital but, above all, to the patient.

With this in mind, the end results have been carefully reviewed in a consecutive series of cases of basically similar nature, subjected to diagnostic exploration by peritoneoscopy or laparotomy during the year April 1, 1939 to March 31, 1940, at the City Hospital, New York. For the purpose of a fair comparison of these two procedures, only those cases have been included in which there were good clinical grounds for suspicion of serious liver involvement but in which it was impossible to differentiate, with reasonable certitude, between two or more of the following diagnoses: carcinoma, cirrhosis, amyloidosis, lues, tuberculosis, hepatitis or biliary tract disease. This group of cases was selected for analysis because it contained the greatest number of patients presenting similar clinical pictures, subjected to exploratory laparotomy or peritoneoscopy.

The series is small but significant. Thirteen such patients were operated upon, seven by exploratory laparotomy and six by peritoneoscopy. Seven different surgeons performed the laparotomies. All the peritoneoscopies were done by the author. All of the patients in both groups were poor surgical risks, but in each case it was believed that the patient deserved the benefit of a diagnostic operation, all more conservative modes of investigation having failed.

Of the seven patients subjected to exploratory laparotomy, a definite diagnosis was made in every case, but five of them died as a result of the operation within two weeks, an operative mortality of 71 per cent. (Table 1.) One patient expired on the third postoperative day, two on the seventh, one on the tenth and one on the fourteenth. The operative morbidity was also impressively high. (Table 1.) Five patients ran a temperature of 101°F. or over for varying lengths of time following operation. There were two cases of wound disruption, one of which completely eviscerated. Two patients showed a severe grade of pulmonary edema; one developed a terminal bronchopneumonia and one died with an acute diffuse peritonitis, proved at autopsy.

In the series of cases peritoneoscoped there were no operative deaths, nor were any postoperative complications encountered. In four of these six patients a definite diagnosis was made, based upon examination of biopsy material. In one of the two cases in which a diagnosis was not made, examination was unsatisfactory due to omental adhesions; in the other, the

electrocautery unit failed during the proce-
dure and no biopsy was taken.

A brief outline of two typical cases, one
explored by laparotomy and one by
peritoneoscopy, will prove of interest.

vomiting. The past history was essentially
negative. Examination revealed an emaciated,
jaundiced male of fifty-nine years who did not
seem to be acutely ill. The liver was enlarged
well below the costal margin; its edge was firm

TABLE I
COMPARATIVE ANALYSIS OF MORBIDITY AND MORTALITY

	No. of Cases	Postoperative Diagnosis	Postoperative Complications	Deaths Due to Operation	Mortality Per Cent
Exploratory laparotomy......	7	Carcinoma 3 Cirrhosis 3 Amyloidosis 1	Fever (101°F. or over) 5 Wound disruption 2 Pulmonary edema 2 Pneumonia 1 Peritonitis 1	5	71
Peritoneoscopy..............	6	Carcinoma 2 Cirrhosis 1 Chronic hepatitis 1 Undiagnosed 2	None	None	None

CASE I. A sixty-three year old colored male
gave a history of recurrent, vague right upper
quadrant distress for one year before admission
to the hospital. There were occasional nausea
and vomiting with a question of recent jaundice
and weight loss. His symptoms had been in-
creasing. The past history included chronic
alcoholism and an untreated lues. Examination
disclosed a chronically ill emaciated negro in
no acute distress. The skin was dehydrated, the
abdomen scaphoid and the liver enlarged to
the umbilicus with a hard, irregular, nontender
edge. A tentative diagnosis of cholecystitis and
cholelithiasis was made. At exploratory lapa-
rotomy the right lobe of the liver was found to
be greatly enlarged. Multiple hard white
nodules were scattered throughout both lobes
of the liver and in the omentum. The stomach,
pancreas, prostate and bowel were palpated
and found to be negative. Postoperative diag-
nosis was metastatic carcinoma, primary site
unknown. The patient's temperature began to
spike to 103 to 104°F. following operation and
he expired on the seventh day with signs of
bronchopneumonia.

CASE II. A fifty-nine year old Italian
laborer complained of loss of weight and
strength for five years, with intermittent epi-
gastric for six months. During the four or five
weeks prior to admission he had been jaundiced
and had suffered from attacks of nausea and

and tender. It was questionable whether a mass
could be felt in the epigastrium. A preoperative
diagnosis of metastatic carcinoma of the liver
was made. At peritoneoscopy the liver was
seen to be slate-grey in color. It was smooth
and rather hard. Its upper surface was studded
with tiny, yellowish, slightly raised, cyst-like
nodules which ruptured easily, discharging a
little serous fluid. A large, stony-hard irregular
mass was found in the omentum. Six ounces of
clear bile-stained fluid were aspirated from the
peritoneal cavity. A biopsy of the liver was
obtained through the peritoneoscope. This was
reported to be a metastatic adenocarcinoma of
the liver. No primary lesion was found on
peritoneoscopy. The patient's immediate post-
operative condition remained unchanged. Tem-
perature, pulse and respiration were unaffected.
The wound healed per primam. However, the
patient slowly wasted away and died one
month later. Autopsy disclosed a carcinoma of
the head of the pancreas with extensive
metastases to the liver and omentum.

The large margin of error possible in
drawing precise conclusions from such a
small series of cases is fully appreciated.
Perhaps in a larger group the mortality
in exploratory laparotomies in these poor
risk patients would not be as high as 71
per cent. But reported fatalities following

peritoneoscopy are rare. That this should be so is not surprising when one compares the magnitude of the two operations.

Peritoneoscopy actually amounts to little more than a paracentesis and is performed in much the same way except that it is surrounded with greater precautions for the safety of the patient. It is performed in the operating room and the patient is so prepared that an immediate laparotomy is possible in the event of any emergency. In the author's experience this has never been required. The operation is done under local anesthesia through a stab wound so small that it is easily closed by a single skin clip. The patient may be out of bed and even return home the same day.

Exploratory laparotomy, on the other hand, requires a major abdominal incision and usually a general anesthesia. It is attended by a certain amount of shock due to unavoidable manipulation of the viscera. There is more or less postoperative reaction and a hospital convalescence of a week or longer must be contemplated. Added to this of course are the possible complications which may attend any laparotomy, chief among which are pulmonary edema, pneumonia and wound disruption. As has been seen, all these complications were encountered among the laparotomies included in this report.

SUMMARY

A comparative review of the end results in a series of consecutive cases subjected to exploratory laparotomy and to peritoneoscopy, for diagnostic purposes, is presented.

From the standpoint of morbidity and mortality, peritoneoscopy is a safer procedure than exploratory laparotomy and it compares favorably with the latter as a diagnostic procedure in selected cases.

New Instruments

AN ELECTRIC BONE SAW AND DRILL*

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IT is as it should be that electrically operated bone surgery instruments are becoming increasingly popular. However, the complexity of the majority of electric bone surgery sets discourages many surgeons from making as frequent use of these instruments as perhaps they should. The instrument to be described has simplicity in its favor.

Each end of the motor unit (Fig. 1A) is represented by a chuck, on one end a standard Jacob's chuck which operates at 2,200 rotations per minute, and on the opposite end a smaller chuck which operates at the unusually high speed of 13,000 rotations per minute. The latter chuck represents a unique feature in that it activates minute burrs which, by virtue of the high speed at which they are rotated, become surprisingly effective bone cutting tools. These burrs (Fig. 1F) which resemble tiny drills, are used in several sizes, but the size most frequently employed has a cutting portion ¼ inch long and 1⁄32 inch in diameter. When rotated at speeds above 10,000 rotations per minute these small caliber burrs cut bone like a saw; at speeds below 10,000 rotations per minute they function merely as a drill. After a little experience, the direction of the cut in the bone may be altered as frequently and as acutely as the case requires. (Fig. 2.)

TECHNIC

The technique for using sawing-burrs is as follows: (1) Burr must be operated at full speed and the foot rheostat kept fully

depressed. (2) To begin the cut the burr is drilled vertically into the bone, using care to prevent penetration of the burr deeper
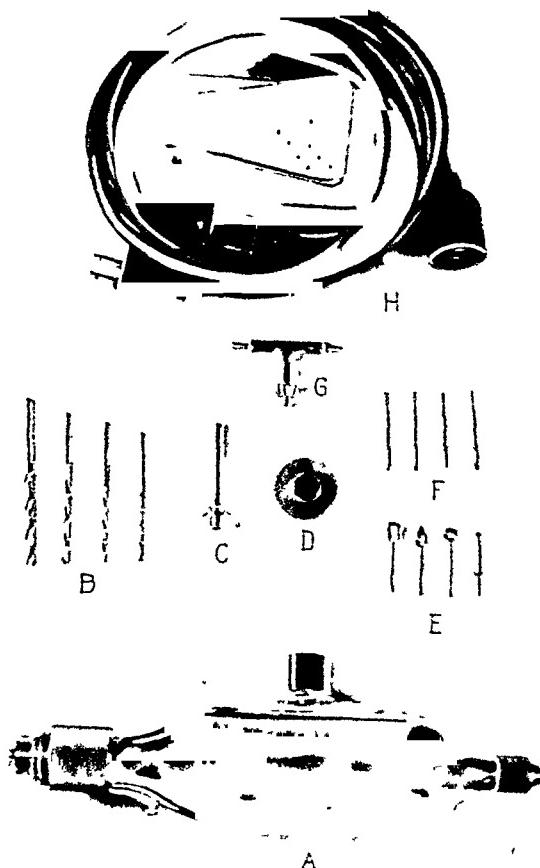
Fig. 1. a, motor unit; b, machinist's twist drills; c, circular saw and mandrel; d, twin saw blade; e, curetting burrs; f, bone cutting burrs; g, key wrench for adjusting Jacob's chuck and circular saws; h, foot rheostat and electric cord.

than its cutting portion. With the burr held in a near vertical position it is drawn firmly along toward the operator. (3) When cutting bone that is thicker than the length of the burr, it is necessary to make succeeding

cuts in the same slot until the full thickness of the bone is penetrated. (4) Saline should be used if the burr generates heat, and may

bone grafts or flaps from the ilium; (6) skull plastics; and (7) laminectomies.

Jacob's Chuck. (Adjusted by key

FIG. 2.

FIG. 3.

FIG. 2. Shows use of small caliber cutting burr in making irregular or curving cuts in bone. By rotating at 13,000 r.p.m. the burr is transformed into a cutting tool.

FIG. 3. Shows twin saws in use. They rotate at 2,200 r.p.m., have abundant power, do not jam, and do not burn the bone.

be applied effectively with a syringe and hypodermic needle. (5) If the cutting surface of the burr becomes clogged, it becomes ineffective and should be scraped clean. (6) Both straight and complex cuts may be made with more accuracy if made along lines drawn on the bone, or along the edges of a pattern.

The uses of the sawing burr are (1) cutting bone grafts of irregular contour; (2) making transverse end cuts in removing tibial or other bone grafts, after the longitudinal cuts have been made with the circular saws; (3) osteotomies, especially of smaller bones; (4) removal of cortical windows in acute osteomyelitis; (5) cutting

wrench, Figure 1G.) Through the interposition of 6 to 1 helical gears, a Jacob's chuck on the end of the motor unit opposite the high speed chuck activates the following at a maximum speed of 2,200 rotations per minute:

Circular Saws. (Fig. 1C and D.) The second, or twin blade, may be adjusted accurately by a set screw for the width of cut desired. For a single cut the second blade is slipped off the mandrel merely by loosening the set screw. Handle tips of the same key wrench (Fig. 1G) which adjusts the Jacob's chuck, serve to adjust the set screws of both circular saws. In using the circular saws the blades are applied gently

to the bone and held at one point until they penetrate the desired depth. Holding the motor unit firmly, the saws are then moved along from right to left. (Fig. 3.)

Twist Drills. (Fig. 1B.) Standard twist drills up to $\frac{1}{4}$ inch in diameter may be used in the Jacob's chuck. Larger size drills may be used if their bases are adapted to the $\frac{1}{4}$ inch capacity of the chuck.

Curetting Burrs. (Fig. 1E.) These burrs frequently are useful in saucerizing a chronic osteomyelitis, curetting bone cysts and treating fracture fragments in pseudarthroses.

Kirschner Wires. Such wires are readily inserted. A special stabilizing mechanism to render them rigid is unnecessary. During insertion the wire may be made adequately rigid by holding it in its middle between towel-covered tips of the thumb and index finger.

Steinman Pins. Any size Steinman pin will fit into the chuck. Since the motor unit has abundant power at low speeds, pins or wires may be inserted without fear of heating the bone.

Sterilization. The entire motor unit together with a segment of the electric cord that connects the motor unit with the foot rheostat are sterilized in the autoclave for twenty minutes under thirty pounds pressure. Sterilization is best carried out several hours before the instrument is to be used to give it an opportunity to cool. However, in an emergency it may be cooled in fifteen minutes by wrapping it in a towel and thoroughly saturating the latter with alcohol or ether. The feasibility of constructing a closed motor unit capable of withstanding autoclave sterilization was first demonstrated by Cox.* This method was adopted and has some advantages over separately sterilizable Hartley-Kenyon shells employed in the Albee and the Kreuscher bone saws. Assembly of the motor into the shells adds to the complexity of the unit, and in some hands adds a danger of contamination.

Construction. The electric motor is universal and operates on 110 volts alternating or direct current. After considerable searching to find a dependable heat resisting insulation for the wire used in the electric motor, a new type of glass insulation was found and employed. Even during profound experimental abuse there were no instances of impairment of the insulation. Both metal and nonmetal gears were used; the combination was found to be quieter and more efficient. Special grease-tight, vapor-proof bearings were employed to prevent the escape of lubricant and the entrance of steam. During two hundred autoclave sterilizations no grease leaked out and no detectable steam entered the casing. Gears and bearings are packed in heat resisting grease which supplies lubrication for the life of the motor unit. This feature removes the inconvenience of periodic lubrication. A streamlined duraluminum case incloses motor, gears and bearings. A waterproof electric connection sets in the middle of the case to receive the plug of the electric cord. Speed of the motor is controlled by a foot rheostat. (Fig. 1H.) Length of the motor unit is $10\frac{1}{2}$ inches, greatest diameter $2\frac{1}{2}$ inches, weight $3\frac{1}{2}$ pounds.

* *J. Bone & Joint Surg.,* 21: 1048, 1939.
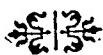
APPENDECTOMY WITH A MODIFIED FURNISS CLAMP

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WITHIN the last decade numerous appliances have been devised to deal with the operative procedures on the gastrointestinal tract, with the object of facilitating technically the removal of pathology with a minimum of trauma and contamination.

The original Furniss clamp has been modified by Clute and McClure to facilitate aseptic closure of the duodenal stump in gastric resection. It occurred to the writer that if these modifications were applicable to the duodenal stump, it certainly could be equally applicable in the most commonly performed enterectomy—appendectomy. The complications of hemorrhage, contamination and leakage in appendectomy are to be avoided as carefully as in duodenal stump closure.

The illustrated clamp is a modification of the Furniss clamp with the handles angulated so as to permit its application in the depths of the abdominal wound, when the cecum is fixed and cannot be delivered. The application of the clamp crushes, shirrs and automatically sews the cecal base. One cannot be dogmatic as to the treatment of the appendiceal stump. Experienced surgeons have expressed their views pro and con ligation and inversion. *Simple ligation* is stated to be dangerous because of the possibility of the stump "blowing out." *Ligation and inversion* is condemned by others because the ligated stump is buried in a closed cavity which may result in a localized residual abscess or generalized peritonitis. *Inversion without ligation* is considered to be surgically sound since the stump is inverted into the cecal lumen and is not buried within the cecal wall.

The late C. H. Mayo gave four reasons why he did not invert the stump: "(1) Invariably, in cases in which appendectomy with inversion of the stump has been done in combination with some other surgical procedure and death has resulted, there is a pus pocket in the inverted stump up to twenty-one days post-operatively; (2) the cultured suture material used to invert the stump, once having run thru the intestinal wall, invariably is infected with pathogenic bacteria; (3) non-inversion shortens the surgical procedure; and (4) I have not had occasion to regret not having inverted the stump."

The writer leaves the treatment of the stump to the good judgment of the individual surgeon, the designed appendectomy clamp permitting either ligation, inversion or both. When the clamp is applied, the cecal base is crushed and shirred. An atraumatic straight intestinal needle is then inserted in the distal or proximal groove and pushed through the crushed base. (Fig. 1A.) The appendix is amputated by knife or cautery and the suture drawn through. (Fig. 1B.) When the clamp is removed, the stump is crushed, shirred and its walls automatically sewn. (Fig. 1C.) At this point the surgeon may simply ligate (Fig. 1D) or may continue the original suture as a seromuscular suture to peritonealize the stump. (Fig. 1E.) For those who choose to invert the stump without ligation, the technic is very simply modified by inserting a pin instead of the straight intestinal needle in the step illustrated in Figure 1A. When the clamp is removed, the cecal base is shirred and temporarily pinned together. A right angle

Cushing stitch is placed and at its completion the pin is removed, inverting the crushed but not ligated stump into the considerably from under the suture, favoring leakage and contamination.

I believe that the ease with which this
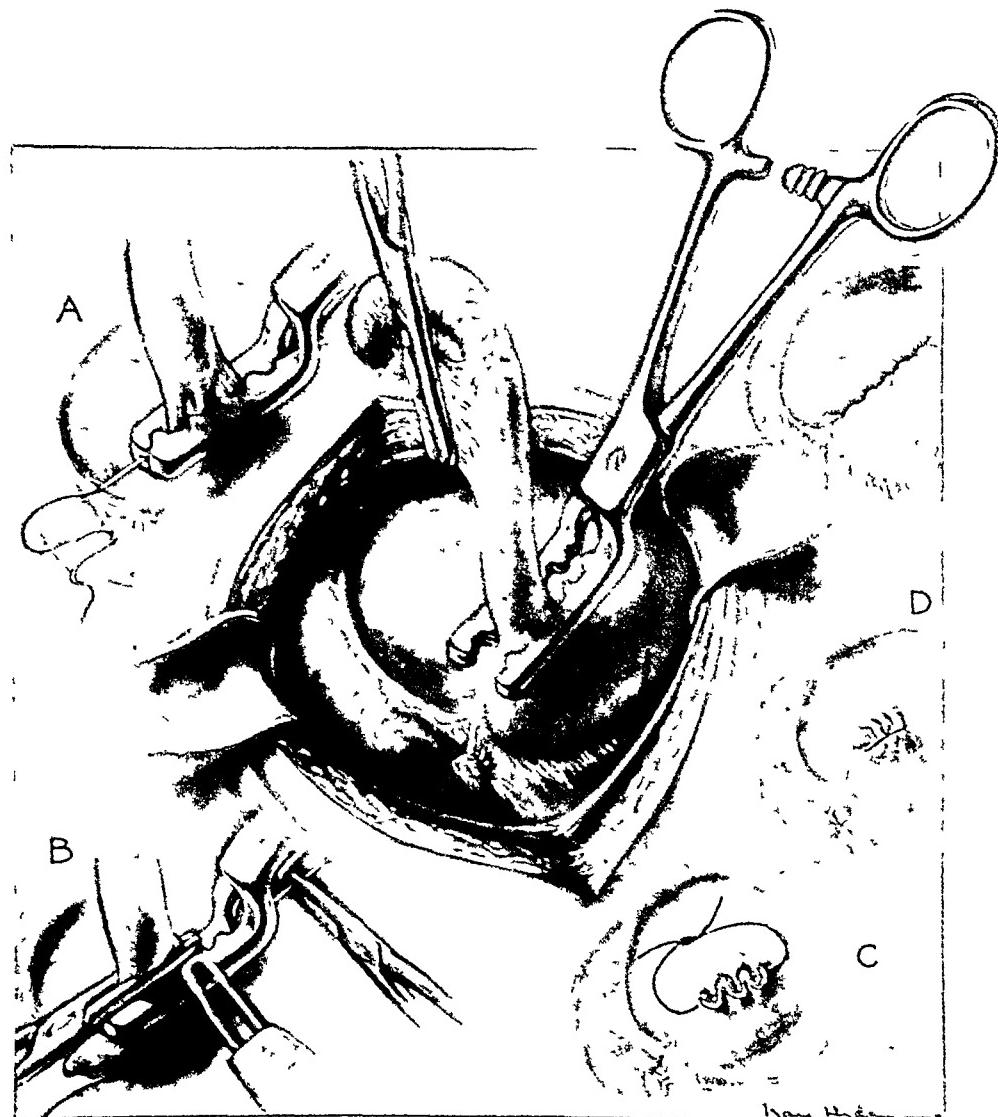
Fig. 1. Illustration showing application of the Furniss clamp as modified by the author in appendectomy. A, an atraumatic straight intestinal needle is inserted at the distal end of the clamp groove, and pushed through the crushed and shirred appendiceal base. B, a crushing clamp placed proximal to appendiceal clamp and appendix amputated with cautery. C, shows the clamp removed, the suture having been drawn through, leaving the cecal base crushed, shirred and sewn together, permitting the surgeon to deal with the stump as he chooses, either tying it (D) or peritonealizing it by a right angle Cushing seromuscular stitch E.

cecal wall. While the same right angle suture may be placed over any toothed crushing clamp, the serrated crushing clamp has to be wiggled and maneuvered modified clamp may be applied to simplify the treatment of the appendiceal stump may merit its addition to the surgeon's armamentarium.

DOYEN TUMOR SCREW

FURNISS MODIFICATION

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THE Doyen tumor screw is a useful instrument, especially in operations for uterine fibroids. However, when

The cup, on the shank of the instrument, compresses the tissue around the shank as the instrument is screwed into
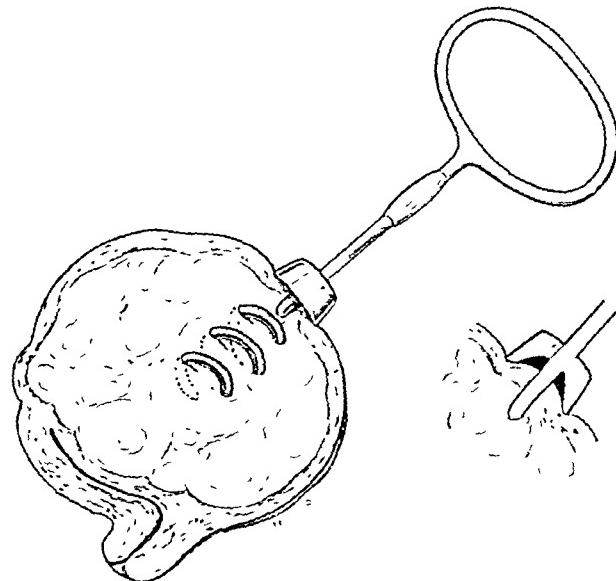
FIG. 1.

the screw pierces a large blood vessel, as occasionally happens, free bleeding may result. To obviate such bleeding the Doyen screw has been modified as herewith described and illustrated.

the growth, thus preventing escape of blood.

This modification has been used with great satisfaction by me and some of my confreres for the past three years.

THE CARNERO

A FISH PARASITE OF MAN AND POSSIBLY OF OTHER MAMMALS

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DURING the months of June, July and August, 1938, the writers were members of a collecting party on the headwaters of the Amazon River in the *montaña* region of Eastern Peru. It was at Yurimaguas on the Huallaga River some 400 miles above Iquitos that we gained firsthand information concerning the interesting fish parasites known by the collective name *carnero* (*candirú* in Brazil) which are alleged to have the vicious habit of entering the urethra of men and women bathers, particularly if they micturate while in the water. While traveling in Peru two years previously, the senior author had heard of these fish from an adventurer. Charley Lamott was a radio announcer, an ex-purser and a general traveler. He was familiar with the *montaña* from Chile to Peru. Fifteen years before he had guided a gold-mining party over the Andes and down the Amazon. While returning from South America in 1936 we had shared the same stateroom, and the strange story of a fish which enters the body orifices was one of the many that he told. On that occasion the writer had listened to the story, smiled knowingly and discounted it as a myth. However, while dicussing the Amazonian fishes with Indians, one of them mentioned a slender fish that attacks people. They became quite excited when telling about the creature but did not make themselves clear as to how the attacks occurred. Resid-

ing in Yurimaguas was Rev. Edgar J. Burns, a missionary with some medical knowledge and experience. When asked about the fish he said, "Oh yes! You mean the *carnero*. It is true that they attack people by entering the body orifices and feeding inside the body. They have spines on the head, and once one starts into an opening the spines prevent it from being withdrawn." The missionary had a wealth of information, and for the next few days the mission fairly buzzed with talk about the carnero. Yet reports of the existence of such creatures seemed incredible.

Tales of these unusual fish have filtered out of the Amazon region for more than 100 years. At first the stories were discredited as fantastic. However, there is no doubt that the creatures actually exist. Dr. H. H. Rusby, the well known pharmacognosist, has traveled extensively through tropical America and is well acquainted with the medical plants of that region. In a letter to us he says, "As to the attacks of the *carnero* on men and women the records are established. Feather-bed explorers and theoretical researchers have disputed the facts, but the evidence is abundant and confirmed."

Dr. Eugene W. Gudger, of the American Museum of Natural History, has made the most extensive study on this subject to date. From the literature he has brought together accounts extending from Martius

in 1829 to G. H. H. Tate in 1926. He also quotes letters from various practicing physicians in the Amazon region who recite their own experiences. In his volume *The Candirú*[1] he has reached the same conclusion as Dr. Rusby.

For the three years previous to our visit Mr. Burns had given medical aid to the Indians in connection with his missionary work in Yurimaguas. Altogether he had worked in the Amazon country for seven years. During that time he had known ten persons who had been attacked by the carnero. In five instances he had had personal dealings with the victims at the time of the accidents, while in the other five cases he had treated the people for hemorrhage after the fish had been dislodged. At one time he had treated three persons within a week.

It will be interesting to note the distribution of sexes and ages in these attacks. Four of the victims were mature women, three were girls ranging from ten to sixteen years of age, one was a mature man and two were boys aged twelve and thirteen. Mr. Burns also added, "Many other cases have been reported, but I have had no definite dealings with the individuals. However, I have conversed with many of these victims at various times afterwards. In most cases the persons attacked were women, men comprising relatively few cases. After several years in this region I am prepared to state that women are the more commonly attacked." This situation is to be expected when one considers the comparative anatomy of the genitourinary organs in the two sexes. Inasmuch as the orifice is much larger in women, penetration is considerably easier. In all cases which came to Mr. Burns' attention the urinary tract had been attacked. Rumors of entrance into the mouth, ears, nostrils and anus were reported, but the missionary was unable to verify them.

In the cases reported by Mr. Burns the pain was generally mild. Males seemed to suffer somewhat more than females. However, the fear element was great in all cases.

From our own conversations with the Indians we concluded that they fear the *carnero* or *candirú* more than the vicious *paña* or *piranha*, which also infest these waters.

Questioned concerning the amount of bleeding, the missionary reported it as being most variable. He said:

"In one instance a sixteen-year old girl came out of the water and did not know that she had been attacked until she saw the blood flowing down her legs. Naturally, at the moment it was mixed with the water running off her body, but even afterwards I had to give her a suitable intravenous injection to stop the flow. In this case the bleeding was most profuse. Also in the case of the man and one boy the blood flow was very great, so much so that the victims were becoming prostrate. Again I had to administer suitable injections to stop the hemorrhage."

Asked whether he had ever known of a person bleeding to death by an attack of this fish, Mr. Burns replied, "No, I have not. The natives speak vaguely of such deaths, but here again there is no real proof. However, I certainly believe death could result, judging by the amount of blood some have lost through the attacks."

The fish in question are small catfish belonging to the family Pygidiidae. These are long, slender fish with weak fins, rasping or file-like teeth and patches of spines on the head and opercula. (Fig. 1.) Members of the group, as shown by Gudger, are known to be secretive, carnivorous and in many instances ectoparasitic on Siluroid fish. The transition to endoparasitism, therefore, is not incredible since we find them living in the gills of many of these large Siluroids, rasping the delicate tissues and feeding on the blood. On this matter Norman says the carneros " . . . habitually live within the gill-cavities of large catfishes and other fresh-water fishes, their slender form enabling them to penetrate between the gills, the sharp teeth and opercular spines being used to start the flow of blood from the host, which is sucked

up by the mouth. The patches of spines on the gill covers also serve to assist the fish to wriggle between the gill-lamellae, and to

alternative since attacks occur as frequently when one is micturating while in bathing as when one urinates into the
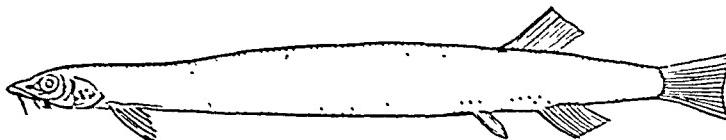
Fig. 1. Lateral view of *Vandellia cirrhosa*, natural size, showing general characters of pygidiid catfishes. (From Gudger after Cuvier and Valenciennes, 1846.)

retain the hold when once established."[2] These features are shown in Figures 1 and 2.

In these cases of internal parasitism there has long been the question as to whether the creatures are urinophilous. We queried Mr. Burns about this. He replied, "I asked one boy about that after he recovered. He said he was urinating in the water when he first felt something and at once rushed out of the river without bathing. However, he had already been attacked. In every case where the people have spoken with any certainty at all the situation seems to be the same as with the boy." Then, in this connection, he related this interesting incident: "A neighbor of mine rushed a cow to his balsa or raft to embark it. The animal did not wish to go on to the craft. As it was urinating, it slipped into the river and came up bleeding profusely—decidedly from the urinary vent. I understand the cow died the same day from loss of blood." His reply to our letter on this point does not state how long the animal was in the water nor how long the attack lasted. Another case of a cow being attacked will be considered later. These instances do not prove that the fish are urinophilous, but apparently urine is a factor to be considered in the attack.

Dr. Gudger[3] suggests three possible interpretations: that these fish are tropic to urine, that they are merely reacting to the current of water and would have so responded if water from the same stream had been poured out of a bucket or tea-kettle, and third that they are attracted by the noise. We are inclined to question the last

water. Concerning this Norman writes, "The little fish appears to penetrate into the urethra especially, if not always, during micturition, and it has been suggested that
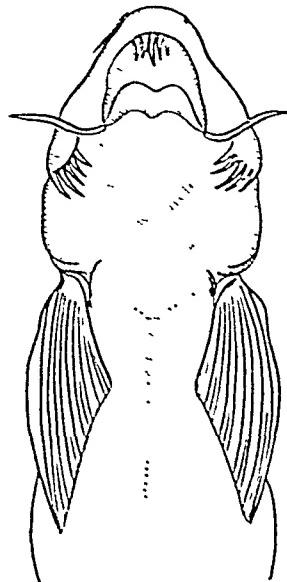
Fig. 2. Ventral view of the head of *Vandellia cirrhosa*, showing ventrally placed mouth with five teeth in upper jaw and inward and backward pointing spines on lower part of each operculum. (From Gudger after Cuvier and Valenciennes.)

it is definitely attracted by urine. It seems more probable, however, that the flow of urine is merely mistaken by the fish for the respiratory current coming from the gill-opening of a fish."[4] These observations are merely recorded here. Whether the parasites are tropic to urine can be settled only by experimentation. However, the present evidence tends to indicate such a tropism.

Numerous reports have been made as to the precautions taken to prevent accident when bathing. In some sections of the
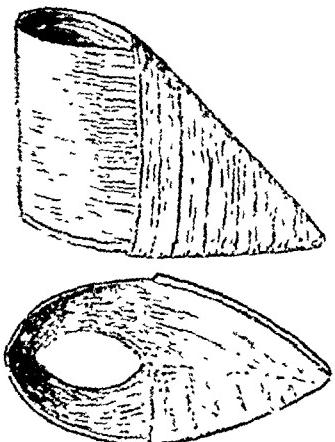
FIG. 3. Lateral and underside views of genital guard worn by men of Kanapé and Tapirapé tribes along Araguana River. (From Gudger after Krause, 1911.)

Amazon the men tie the prepuce with a string. In other regions sheaths woven from palm leaf fibers are worn by both men and women. Such sheaths are known to be used by the natives living on the headwaters of the Tocantins and Xingu Rivers of the Amazon system. Gudger figures and describes three of these, and of these three we reproduce one in lateral and underside views. (Fig. 3.) At Yurimaguas apparently no such devices were used. Most of the people do not even enter the water when they bathe. They are afraid of the carnero and prefer to pour water over themselves from calabash containers. Only the younger children enter the water without anything on. The adults almost always use some sort of pants. Possibly the fact that these people have a dependable cure may be a factor in this lack of special protection.

Once the fish has attacked, the treatment seems to vary in different regions of the Amazon. Many explorers report immediate surgery as the only type of relief. In 1897, Dr. G. A. Boulenger, Curator of Fishes at the British Museum of Natural History, quoted Dr. J. Bach, a physician in active service on the Jurua River, as contending that the only means of preventing the fish from reaching the bladder, where it causes inflammation and ultimately death, is to operate immediately. He also records the examination of four natives, a man and three boys, in which the penis had been amputated as a result of this dreadful accident. We were unable to find such serious consequences at Yurimaguas.

Here the locally recognized and only treatment used is that of the *builo* or *Jagua* fruit. We collected this fruit. It has been identified by Mr. Charles Gilly and his identification confirmed by Mr. B. A. Krukoff and Dr. Albert C. Smith, all of the New York Botanical Garden, as *Genipa americana* L., the fruit of a common tree in the tropics of Central and South America. (Fig. 4.) The only references to this treatment which we are able to find are in the writings of Poeppig (1836) and Marcoy (1869) as quoted by Gudger. Even here it is to be noted that Poeppig uses the spelling *Xagua*. However, there seems to be no doubt that it is the same fruit in all cases. We quote first from Poeppig: "In Yurimaguas I myself have been an eyewitness of such an attack. An Indian woman, after an attack by a *Carnero* into the vagina, suffered such frightful pain and loss of blood that she was given up to die. However, after both internal and external applications of *Xagua*, the little fish was gotten out and the woman came through alive."[5] And Gudger quotes Marcoy as follows: "To the horrible sufferings which the introduction of this living needle may occasion, the Ucayali doctors know of but one remedy which consists of a *tisane* made with the *genipa* or *builacb* apple, and which, taken very hot, acts, they pretend, on the urinary passages, and dissolves the animal which obstructs them."[6]

Both Dr. H. H. Rusby, referred to previously, and Dr. Paul C. Standley, Curator of Botany at the Field Museum of Natural History, are familiar with this tree, but neither had ever heard of the juice of the unripe fruit being used in treating attacks

by the carnero. Dr. Rusby writes to us that: "The juice, when unripe, makes a fairly good indelible ink, and I have often thought that it might be so treated as to make it commercially valuable for that purpose, or for dyeing. I have never heard of its use in the treatment of *candiru* lesions and do not see how, in the nature of the case, it could be of service. This fish forces its way into the urethra as far as possible and cannot be removed without severe surgical operation because of the spreading of its fins. The damage is thus mechanical, and there is nothing specific that can be done in treatment. This astringent juice would doubtless tend to check the hemorrhage."

All that Dr. Standley has to say concerning this fruit is that: "Upon cloth and other articles the juice produces a brownish or blackish permanent stain, hence it is much used by the primitive inhabitants of the region for dyeing, and especially for painting the body."[7] We found that if the green center is rubbed on the skin it turns black very soon afterward and remains so until it wears off. Certain of the natives along the Huallaga seemed to think that it aids in repelling insects and curing insect bites. At least when insect pests became too abundant the natives often painted their legs, arms and even their faces with this juice. Opinion as to its effectiveness seemed to be divided.

As stated above, the unripe jagua fruit (Fig. 5.) is the standard treatment for dislodging the carnero once it has attacked. The centers of the smaller green fruits are scraped out, mashed and squeezed and mixed with water, the strength of the preparation varying considerably. The potion has a bitter taste and the puckering effect of a fairly strong astringent. The preparation is taken by mouth. In a comparatively short time, varying from a few minutes to about two hours, according to the natives, the fish is dislodged. Mr. Burns states that, although this cure sometimes causes the patients to become quite nauseated, he has never known the treat-

ment to fail, nor can he learn of a failure from the natives. Neither has he ever known the fish to be dislodged without this form of treatment.

Fig. 4.

Fig. 5.

Fig. 4. The *jagua* tree, *Genipa americana* L., which is found throughout tropical Central and South America. The birds on the branches are vultures. (Photograph by Ralph Davis.)

Fig. 5. Unripe *jagua* or *huito* fruit, *Genipa americana* L., the juice of which is used to dislodge the carnero once it has attacked. (Photograph by W. Hugh Stickler.)

It appears that in the region of Yurimaguas, as well as in a number of other settlements along the lower Huallaga River, the juice of the green *jagua* fruit has for generations been administered in the case of attacks by the carnero. At least in

1938 everybody knew about the treatment and conversed freely concerning it as they did in Poeppig's day—1836. The fish is reported to have been successfully driven out of the host's body so frequently that it is difficult to believe that the desired results have occurred as timely accidents in such a large number of cases. But in the absence of scientific proof the best we can do is to speculate in the matter.

Even after leaving Yurimaguas on the Huallaga River, and while traveling along the Ucayali for eight or nine hundred miles, frequent inquiries disclosed the fact that the natives along the whole length of the lower river were familiar with the carnero and feared its attacks. When asked what to do in case a carnero should attack us, the jagua juice was invariably mentioned as the cure. On one occasion while traveling through the native town of Pucalpa, some eight hundred miles up the Ucayali, the senior author stopped an Indian under a *jagua* tree and asked, "Does this tree have any medicinal value?" "Si, si, senor," he answered, "It is used in driving the *carnero* out of your body when it is eating you."

Again picking up our story in Yurimaguas, two cases will serve to show the nature of these attacks and the treatment employed. In the case of the ten-year old Indian girl, the fish had been lodged in her genitourinary passage for six hours before it was finally driven out by the native treatment. The Peruvian doctor, who had only recently arrived in this section from the dry west coast of Peru and who was not familiar with this phenomenon, said the fish would have to be removed by surgery. The girl's parents refused consent and brought the case to Mr. Burns. He sent for several of the older and most reliable Indians and asked them about the native cure. They all agreed that the green fruit of the *huito* or *jagua* tree would drive the fish from her body. He told them to administer their customary treatment. They said the fish came out, but the missionary never saw it, their excuse being that the chickens had eaten it when it was put aside. Some three

hours later the parents called again, and Mr. Burns gave the girl a suitable hypodermic injection to stop the hemorrhage. The injured organs in the girl's body became infected, and she was quite ill for several weeks. Under Mr. Burns' care she finally recovered and seemed none the worse for the experience.

Another gruesome case was that of a thirteen-year old boy. The fish had entered his penis, and by the time the young Indian had reached the mission a half hour after the attack his trousers were saturated with blood, and it was running over his bare feet. He seemed to be in considerable pain. Mr. Burns, fearing that he might not succeed as the Indians do with their huito juice, said that he had no medicine for such cases. He suggested that they treat the boy according to their own customs and lost no time in sending the Indians for the fruit. This time they had to cross the river, over one-fourth of a mile wide at this point, to get green fruit. There was plenty of ripe fruit at hand, but this is not suitable for the treatment. The men brought the green fruit, prepared it, and gave the boy a good drink, about a pint, of the unpalatable medicine. This, of course, could be prepared in varying strengths. The next day, hearing that the boy was very weak from loss of blood, Mr. Burns went to his house and was told that the fish was dislodged about two hours after the potion was administered. The boy was still suffering with a slight hemorrhage, and micturition was painful. However, he recovered completely.

Not only human beings but also domestic animals as well are attacked by these fish. The case of a cow reported as being attacked and killed has been noted. Mr. Burns stated that in order to prevent their bleeding to death many cows had been slaughtered. Such attacks are made easy by the custom of bringing the cattle downstream to the local market at Yurimaguas by making them swim alongside a dugout. The animals may be in the water for lengthy periods. Considering the number

of animals brought to market in this manner, the number of attacks is relatively few. One instance is worthy of consideration since it shows the extensive loss of

who dressed the carcass all declared it was the result of an attack by a carnero. Mr. Burns completely discredits the possibility of an attack by piranha in this instance.

FIG. 6. Two specimens of carneros hanging on the finger by means of the spines on their opercula. (Photograph by Ralph Davis.)

FIG. 7. A close-up of Vandellia plaizae. (Photograph by Ralph Davis.)

blood during a severe attack. It happened that the cow was white, and hence the spectators noticed her bloody coat as soon as she climbed the river bank after her two-hour swim downstream. The owner, seeing that the animal was very weak, called for assistance. Mr. Burns reports that she was half-carried, half-dragged by the men to the nearby slaughter house. When her throat was slashed the surprised bystanders found that very little blood flowed from her veins. The creature bore no sign of external injury nor sign of ill treatment by man, stick, or piranha. The men

After the cow was slaughtered the missionary examined the parts affected. He reports that: "Slight lacerations were to be found some three inches more or less up the urinary tract. Seemingly only this region was attacked since the vaginal and uterine tissues showed no injury. The lacerations were not extensive but appeared somewhat raised and whitish." The fish, however, had escaped. The carcass was eaten by the natives.

This brings us to another interesting point. Several times Mr. and Mrs. Burns had tried to eat the flesh of cows that had been slaughtered after an attack by the

carnero, not, however, in the case just mentioned. In each instance they reported that the flesh was "most distasteful." Mr. Burns added, "Very little trying was sufficient, and the meat was thrown out. It had a strong taste. In each instance the animal had been brought to town swimming alongside a dugout when the attack was made. Whether different grazing conditions upstream could make the difference in taste we are not sure." When asked whether their psychological reactions might not have entered into the consideration, Mr. Burns steadfastly maintained that: "Under no circumstances could it have been our psychological reactions because we did not know what had happened until we inquired afterwards." We offer no explanation here, but we do believe this account is worthy to be recorded.

Upon learning that the carneros could be caught by using a large piece of bloody meat, we spent two long afternoons fishing for them. The first time we used a cow's lung, which we repeatedly sopped in blood, and captured two nice specimens. On the second occasion turkey viscera sopped in turkey blood was offered but with no success. The turkey viscera sank so deep in the water that it was eventually consumed by the small piranha. The lung was floated in such shallow water that the piranha did not bother it so much.

When the slithery carneros found the bloody meat, the dip net was not necessary to capture them for they writhed about and literally wormed their way into the flesh. When the lung was lifted from the water they clung to it with their spines and were removed only with some difficulty. In the same way they clung to the finger of their captor as shown in Figure 6. These specimens have since been identified at the American Museum of Natural History by Mr. John S. Robas as *Vandellia plaizae*, one of the specimens known to attack man. Of course, there are a considerable number of other species in the family Pygidiidae which also are known to have this unusual habit of endoparasitism.

Our specimens were between five and six inches long and were of a diameter rather less than that of a lead pencil. We were led to believe that most of the offenders are considerably smaller than this. Our fishes were light in color, had smooth skins, and each had a pair of short "feelers." Hand lens magnification showed four rounded clusters of curved needle-like spines on the fish's head. A pair of spine clusters were on the margin of the gill covers were up on each side of the head, and two were on the opercula underneath. The mouth was somewhat sucker-like with a number of rasping spines or teeth in the upper jaw.

Figure 7 is made from a photograph in oblique-dorsal view and hence does not show the details referred to in the preceding paragraph. These details may be seen in the drawings reproduced in Figures 1 and 2. Figure 7 does, however, give an idea of the general form of the body, tail and fins. As far as we know, these are the only photographs of the carnero ever published.

The little fish are extremely bloodthirsty. Even after the lung was lifted from the water, the vicious little creatures continued to crawl about the bloody surface biting and chewing as they went. One of the specimens found an opening in the lung and almost disappeared by rapidly wriggling its way inside. When an attempt was made to pick up the live specimens, their instant reaction was to turn and bite the offending fingers. The bite of these fish was like the rasping of a coarse file (Fig. 2) and, like a file, would draw blood if applied too often in the same spot. Without a doubt this fish can cut through tender mucous tissue in a short time, if not with the first rasp.

Since we had two live specimens, this seemed an excellent opportunity to test the effect of the jagua juice on them. Although the water in the large container in which the fish were kept was changed several times during the night, one of the fish was nearly dead and the other quite sluggish the following morning. The jagua was collected and the juice prepared as quickly as possible. Then the livelier specimen was placed

in the dilute mixture. The little fish became suddenly active and, after swimming around rapidly and showing other signs of discomfort for about two minutes, turned over on its back and remained motionless. The fish was not dead, however, for upon being placed in fresh water it revived. It was unfortunate that we did not have more live specimens with which to experiment for the vitality of this one was at low ebb, and the reaction may not have been normal.

At the present time there seem to be two interpretations of the manner in which the fish injures its host. Some well known scientists, including Dr. H. H. Rusby, think that the injuries are of a mechanical nature only and are caused by the fish as it uses its needle-like spines to work its way in the tender tissues. Others hold that the carnero feeds upon blood and uses this method of finding tender membranes that it can rupture easily with its rasping teeth. We are inclined to subscribe to the latter viewpoint. It is definitely known that the Pygidiidae are secretive and ectoparasitic and that some of them are endoparasitic. It seems reasonable to suppose that a fish that has taken the trouble to work its way inside of a host's body has done so because of some strong instinctive urge. Since there is such profuse bleeding in many cases it is logical to believe that the fish has sought this location for the purpose of feeding on blood and possibly the tender tissues. In fact, the bleeding is so out of proportion to the size of the lacerated area that we are tempted to speculate on the possibility that the fish passes the blood through its own body at a rapid rate in addition to the hemorrhage from the mechanically injured tissues. That, however, would be purely conjecture. Nevertheless, carneros greatly distended with blood have been reported. For instance, Gudger[5] quotes Eigenmann as capturing *Vandellia sanguinea* " . . . gorged with blood." The bloodthirsty dispositions of the live carneros and the frenzied manner in which they attacked the bloody lung when they were being cap-

tured also indicate that the fish in question had avid appetites for blood.

Assuming that the fish feeds on blood, it appears possible that the jagua juice may contain some chemical substance that will affect the blood sufficiently, possibly by making it distasteful, to cause the fish discomfort and to stop the feeding process. One might reasonably expect that once the feeding had stopped the fish would attempt to dislodge itself. Here we seem justified in venturing the conjecture that the head and opercular spines are under muscular control and can be withdrawn when the fish so wills. The case of the white cow seemed to indicate that the fish had returned to the water when they had practically exhausted the animal's blood supply. However, among human victims we heard of no case wherein the fish became dislodged without the *jagua* juice treatment.

Many questions arise in connection with these strange creatures. How does the fish obtain oxygen while in the host's body? How long can it live as an internal parasite? Will it eventually leave the host of its own accord? Is the creature attracted by the odor of urine? Is it really a blood-feeder or are the injuries purely mechanical? If it is a blood-sucker, what does it feed upon when it cannot find blood? How does the *jagua* juice bring about the dislodgement of the animal? Since these fish attack man and cattle, may they not also attack the warm-blooded manatees and porpoises which inhabit the waters of the Amazon? These and other problems offer unusual disclosures to the scientist who can unravel them.

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Selected Book Review

ABDOMINAL SURGERY OF INFANCY AND CHILDHOOD*

BY WILLIAM E. LADD, M.D. AND ROBERT E. GROSS, M.D.

WHEN the editors of The American Journal of Surgery decided to devote an entire issue to the Surgical Diseases of Children, they surveyed the field in quest of a Guest Editor who was pre-eminent in this field. Finally, they decided on William E. Ladd. He accepted the assignment and the popularity and extraordinary worth of that number is now history. Therefore, we were not surprised to learn that he and Dr. Gross had written a complete work entitled "Abdominal Surgery of Infancy and Childhood" which has been published by the Saunders Company. Upon the receipt of this book for review we immediately sought from those in the profession, who had the book and whose opinions were reliable, an expression of their views regarding this work. In every instance the response was the same: "Good." Some called it "marvelous," "very much need" or "top-notch." After carefully going through its pages we, too, can use any of the adjectives denoting its superiority and excellence.

Twenty-five years ago the late Dr. James S. Stone first fostered the idea of devoting the major part of the time of the surgical staff of Boston Children's Hospital to pediatric surgery. As the authors state, "This does not imply that pediatric surgery should always be set apart as a separate specialty, but it does indicate that infants and children can obtain improved surgical care if an appropriate number of men in each community will take a particular interest in this field and give it the attention which it rightfully deserves."

This book, which is devoted to that part of children's surgery which involves the abdomen, was written with the intention of developing better methods of examination, more detailed preopera-

* Philadelphia, 1941. W. B. Saunders Company.
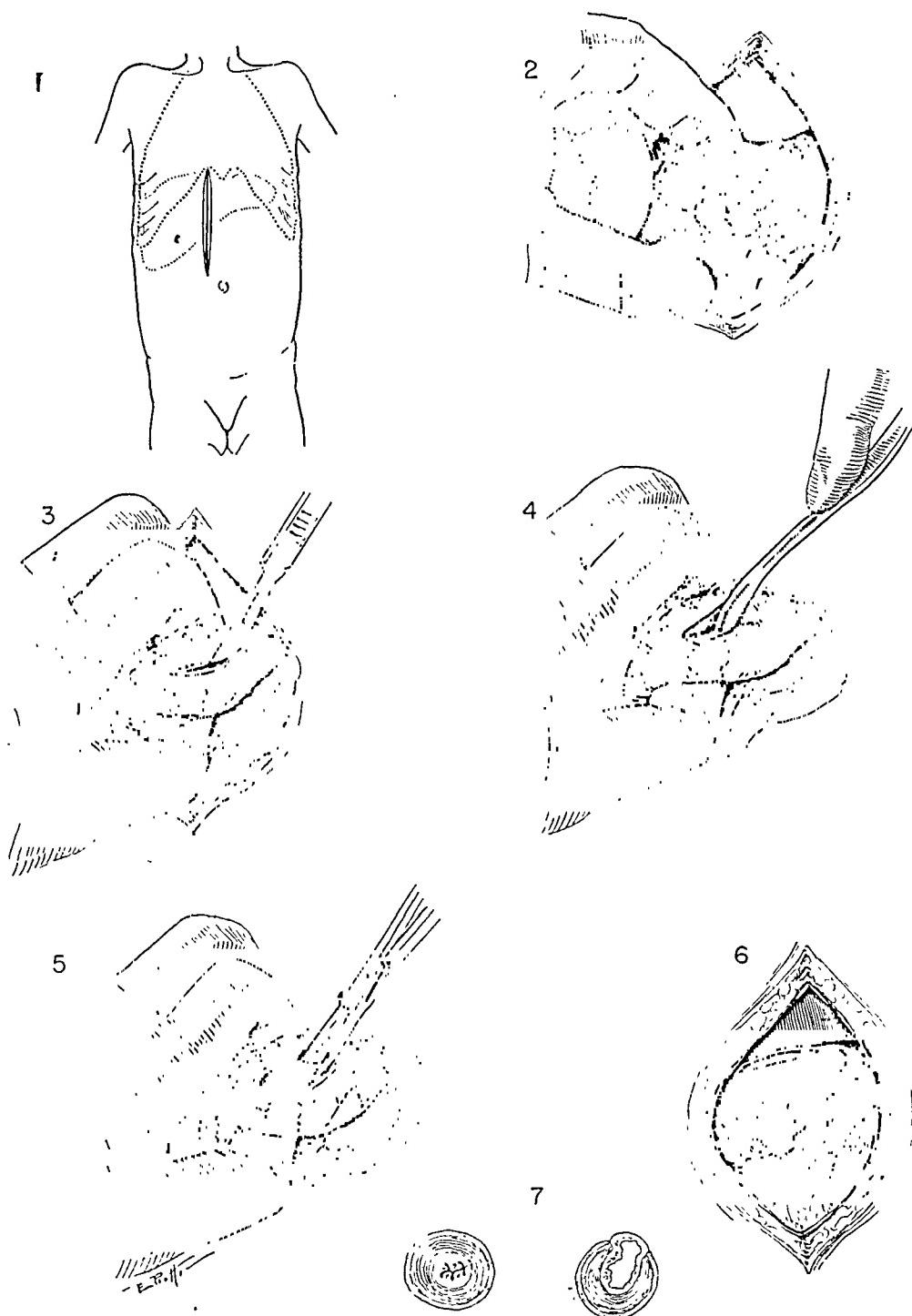
Fig. 1. Steps in operative treatment of congenital hypertrophic pyloric stenosis. 1, position of the skin incision. Right rectus, muscle-splitting incision. 2, delivery of the pylorus up into the operative wound, 3, pylorus held between two fingers, and rotated downward so that incision can be made along its superior surface where the vascularity is minimal. Incision carried through only the serosa and superficial muscle fibers. 4, division of the deeper muscle fibers with a blunt instrument. A rounded handle of the scalpel serves best for this step. 5, separating the edges of the muscular coat with a hemostat, so that the mucosa is exposed and is allowed to bulge up into the muscular defect. 6, pylorus dropped back into the abdomen, showing the pyloromyotomy on its superior surface. 7, cross section of hypertrophied pylorus before operation (*left*) and after operation (*right*). Following operation the mucosa pouts up through the muscular slit to the level of the preexisting serosa. (Fig. 6, on page 12, in Ladd and Gross' "Abdominal Surgery of Infancy and Childhood." W. B. Saunders Company.)
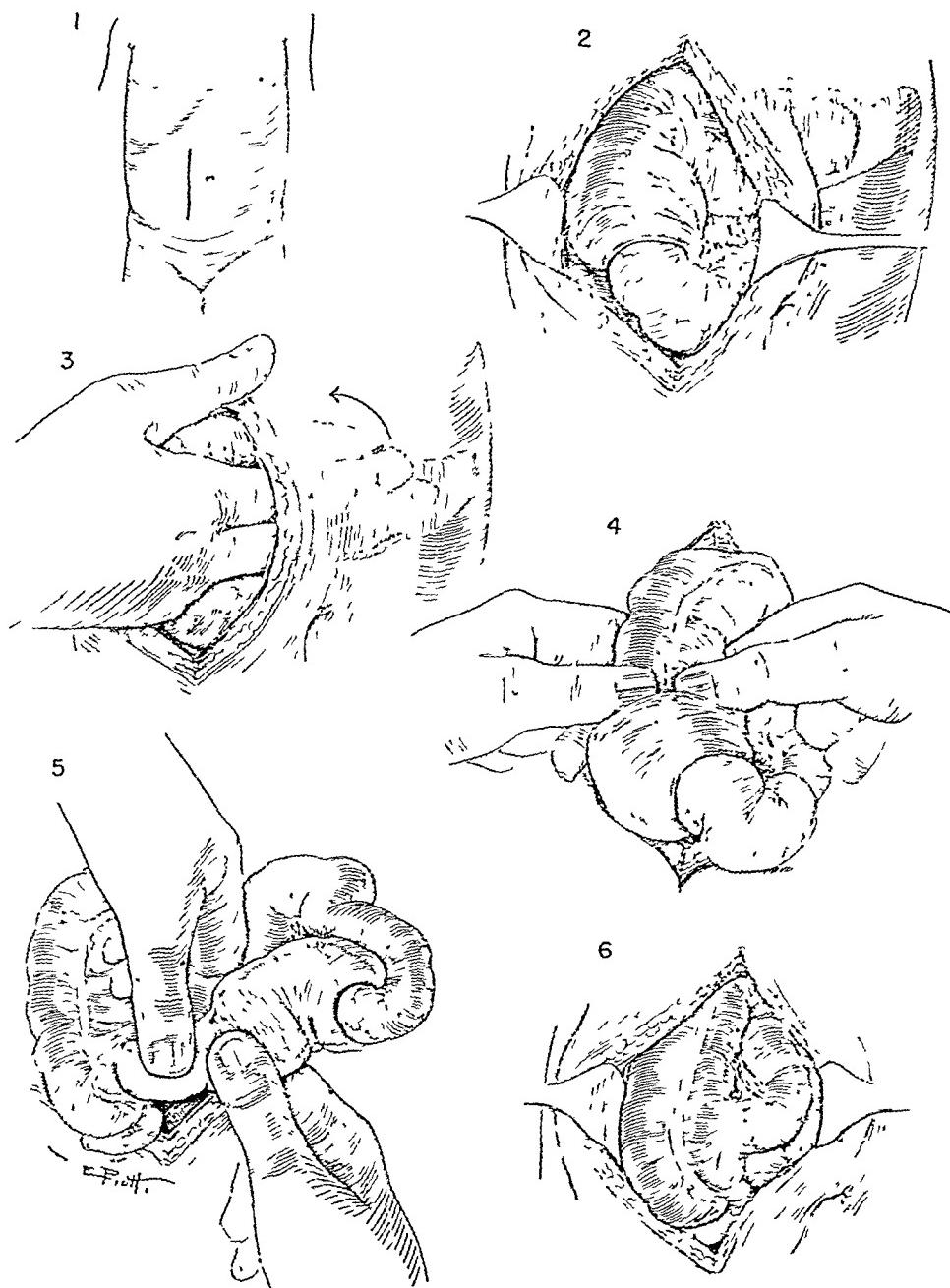
Fig. 2. Method of operative reduction of ileo-colic intussusception. 1, incision is always made on right side of abdomen, regardless of position of palpable mass. 2, findings on opening abdomen. Ileum is intussuscepted into ascending colon. Intussusception extends almost to the splenic flexure. 3, portion of hand passed in to left side of abdomen so that the finger tips can push back intussusceptum in direction of arrow. 4, intussusception has been reduced to the ascending colon which is now delivered out of the abdomen. Squeezing over the distal end of the mass is now begun. 5, cecum and appendix have been delivered. Remaining intussusception in ileum is reduced by continued squeezing on the receding mass. 6, reduction completed and intestines returned to abdomen. (Fig. 7-, on page 116, in Ladd and Gross' "Abdominal Surgery of Infancy and Childhood." W. B. Saunders Company.)

tive and postoperative care and a more specialized and delicate operative technic. The authors have lived up to this blueprint to the letter. For many years the authors and their co-workers intended

Fig. 3. Male infant with imperforate anus (Type 3). *Left*, appearance of perineum at one day of age, prior to operation. *Right*, appearance of anus two months after proctoplasty (sphincter muscle has good tone). (Fig. 112, on page 174, in Ladd and Gross' "Abdominal Surgery of Infancy and Childhood." W. B. Saunders Company.)

to gather the subject matter which would result in this book but inadequate financial backing postponed the effort until a generous grant was received from the Godfrey M. Hyams Trust Fund which made it possible to bring the work to completion.

The contents include chapters on congenital hypertrophic pyloric stenosis, peptic ulcer, gastrostomy, congenital atresia of the intestine and colon, congenital stenosis of the intestine and colon, intestinal obstruction resulting from malrotation of intestine and colon, Meckel's diverticulum, duplications of the alimentary tract, foreign bodies in the gastrointestinal tract, intussusception, polyps of intestine and colon, congenital megacolon, chronic idiopathic ulcerative colitis, malformations of the anus and rectum, primary peritonitis, appendicitis, hiac adenitis, omental cysts and mesenteric cysts, diseases of the spleen, congenital atresia of the bile ducts, obstructive jaundice from inspissated bile or mucus in the biliary passages, idiopathic dilatation of the common bile duct, cholecystitis, cholelithiasis, hepatic tumors, anomalies of the

gallbladder, injury to the extrahepatic bile ducts, rare conditions of the umbilicus and abdominal wall, omphalitis, omphalocele, umbilical hernia, congenital hernia of the diaphragm, intra-abdominal hernia, inguinal hernia, hydrocele, undescended testis, tortion of testis and appendix testis, diseases of the female genital tract, exstrophy of the bladder, embryoma of the kidney and neuroblastoma sympathicum.

A Bibliography (only when necessary to supplement the authors' material) is at the end of each chapter. The illustrations (about 270 in number) are very well done and there is an elaborate Index.

It goes without further saying that this book should be owned and read carefully by every surgeon who is called upon to diagnose and operate upon abdominal surgical conditions in infants and children. It is one of the year's most important contributions to the surgical field.

S P E C I A L   M O N O G R A P H

CESAREAN SECTION

The Modern Operation

BY

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INTRODUCTION

CESAREAN section is a comprehensive term for all the operations which have been devised to effect the delivery of the child through an incision in the abdominal wall and the uterus. Laparotomy for abdominal pregnancy and rupture of the uterus during pregnancy and labor is not included. Vaginal cesarean section is misnamed.

The operation itself is of great antiquity. Its history has been so often written that it will not be repeated in detail here. For centuries results were so bad that it was merely an operation of last resort, performed after failure of infravaginal delivery. In the United States, hardly more than fifty years ago, cesarean section was a formidable operation with about 60 per cent mortality. Because of its hazards it was held "chiefly justifiable in cases in which craniotomy and the delivery of the child through the natural passages involve the life of the mother in still greater peril, and indicated therefore in extreme pelvic contraction, in the case of solid tumors which encroach upon the pelvic space, and in advanced carcinomatous degeneration of the cervix."[61] Many operators did not suture the uterine incision at all but were content with uterine contraction initiated by friction and the use of ice. Women died of sepsis and hemorrhage then as they do now. Kehrer,[51] not Sanger, really deserves credit for priority in the modern operation, for in 1881 he performed a new type of cesarean section through a transverse incision in the lower uterine segment at the level of the internal os, and closed the uterine muscle and overlying peritoneum separately.

[1]

THE CESAREAN FACTOR IN PUERPERAL MORTALITY

Improved technic has so widened the indications of even a few years ago, that many have come to believe that cesarean section is safe enough for all obstetric difficulties, even minor ones. Yet cesarean section occupies a very prominent place in puerperal mortality. Statistics in support of this statement are available from almost every section of the United States, yet excellent results in large numbers of cases are reported by skillful operators who exercise good judgment in the selection of patients and the proper type of operation.

The Obstetric Advisory Committee of the Children's Bureau[95] commenting on maternal mortality in fifteen states defined cesarean section as an abdominal operation to remove a viable fetus through a uterine incision and found it "evident . . . that poor selection of cases and unwise selection of the type of operation were frequent. The number of classical cesareans done for abnormal presentation after delivery from below was attempted was astounding. Forty-five per cent of all the women who had cesarean section had had more than one pregnancy. Local anesthesia was used in surprisingly few cases. The tremendous mortality attending cesarean section throughout the United States warrants a careful review of the indications for the choice of operation."

In New York City from 1930 to 1932, 19.8 per cent of all maternal deaths were preceded by cesarean section.[71] In 1939, in 108,018 terminated pregnancies, 2,558 cesarean sections were performed with a mortality of sixty-eight or 2.7 per cent, yet 21.3 per cent of all puerperal deaths followed cesarean section; twenty-seven of these deaths occurred in the Borough of Brooklyn, contributing 24.5 per cent to its total puerperal mortality.[32] Hemorrhage and shock were common immediate causes of death.

DeNormandie,[19] reviewing the number of cesarean sections in Massachusetts in 1937, found an incidence of 1 in 30.3 births. Irving[46] found that 24 per cent of all puerperal deaths in California in 1928 followed abdominal delivery, while in Boston, from 1933 to 1935, 27 per cent of all puerperal deaths were preceded by cesarean section.

Lynch[62] states that "more than one-half of the deaths following section have occurred in women who previously had borne children through the normal birth passages. And furthermore 0.76 per cent

of all women delivered in the United States in 1934 were by cesarean section."

Since death following cesarean section is often not due to the operation itself, Schumann[85] insists that mortality should be assigned to cesarean section only when due to the unavoidable complications of intraperitoneal surgery like pulmonary or cerebral thrombosis, rarely peritonitis, and still more rarely postpartum hemorrhage. After vaginal delivery, he points out, death is assigned according to the underlying cause, as for example, eclampsia, abruptio placentae and puerperal septicemia. Statisticians, however, must assign cesarean section deaths to the international list numbers 149 (other accidents of childbirth), 146 (puerperal hemorrhage), 147 (infection during childbrith and puerperium), and 144 to 148 (the toxemia group).

The puerperal death rate in the United States has decreased 11 per cent from 49 per 10,000 in 1937 to 43.5 per 10,000 in 1938, and it appears that the rates for 1939 and 1940 will be still lower; yet the rising incidence of cesarean section with its high average mortality promises to destroy our obstetric gains. Improved surgical technic has properly widened the range of operation, but appreciation of the importance of contraindications to cesarean section has lagged behind. Those who are unable to assess the risk of cesarean section or are incompetent to weigh its indications and contraindications, should not perform the operation, whatever their technical ability.

INDICATIONS

Contracted Pelvis. In severe pelvic contraction, as a rule, cesarean section is indicated when the child is alive, and craniotomy if it is dead. Infection may be so severe, however, that election of abdominal delivery should be very seriously questioned. When pelvic contraction is so great that vaginal delivery of a dead fetus by embryotomy is not possible, the indication for cesarean section is absolute. Thus, with a diagonal conjugate of 9.0 cm. or less, delivery of a living full term baby is practically impossible, and cesarean section will be necessary. Cesarean section is so clearly indicated in major degrees of pelvic contraction, that it should be elected before labor begins.

In moderate pelvic contraction with a diagonal conjugate between 9.5 and 11.0 cm. cesarean section is often elected, yet spontaneous delivery may follow good labor. In the majority of cases of

minor pelvic contraction, with a diagonal conjugate below normal but not less than 11.0 cm. it is likely that spontaneous delivery will occur. In some cases, however, it is difficult to know beforehand whether pelvic delivery is possible or not. Molding of the vertex is variable and depends on the consistency of the fetal head; and the size of the fetus is an important factor. Presentation and position must be given due weight, and good labor is essential. The patient's age, behavior of the soft parts and the time of rupture of the membranes must also be taken into consideration.

Severe outlet contraction, if established, is a proper indication for cesarean section, yet a narrow pubic arch and short transverse diameter may be well compensated in the hind pelvis. In cases of short bisischial diameter the sum of the bisischial and posterior sagittal diameters should equal 15 cm. for infravaginal delivery to be possible with a baby of average size.

The majority of women with contracted pelvis may be delivered satisfactorily by the vaginal route. Müellers method of fitting the head into the pelvis has some value. If the lowest level of the vertex can be forced into the pelvis as far as or below the level of the spines, good labor should result in vaginal delivery. If overriding cannot be overcome, pelvic delivery is possible though unlikely. Occasionally, the soft parts prevent the fetal head from engaging. Slow dilatation of the cervix is a proper indication for cesarean section only when there is grave doubt of pelvic delivery.

We have become more and more aware of the limitations of pelvimetry by other than roentgenographic methods, yet as a rule the diagnosis of contracted pelvis is made without the use of x-ray, and measurement of the diagonal conjugate is generally held to be a reliable index of pelvic capacity. Thoms[94] has said, "A reasonable effort should be made to measure the diagonal conjugate, always remembering that the calculation of the true conjugate may not be accurate, and that marked shortening of the transverse diameter of the superior strait may be present, with no shortening of the true conjugate."

Caldwell and Moloy[10] "are opposed to the use of roentgen methods on the results obtained from mathematical formulations of a few pelvic and fetal diameters." They say that while "exact diameters may be attained by roentgen methods in actual practice, the significance of these measurements is difficult to determine. One of the serious drawbacks to the use of a few cardinal diameters as a

basis for prognosis is the fact that compensatory space does not enter into such calculations." Stereoroentgenography, however desirable, is not as practical for the average hospital as the grid method of Thoms, an excellent and a very much simpler procedure.

Roentgenometric pelvimetry gives us accurate information on the topography of the pelvis, yet the power of the expulsive forces and the capacity of the head for molding and adjustment to the pelvic brim are very difficult to determine; nor can x-ray be trusted to provide us with accurate knowledge of the relationship of the size of the fetal head to the pelvis. The patient with the borderline pelvis or cephalopelvic disproportion presents a very serious problem indeed. There can be no doubt that this diagnosis is responsible for a great many unnecessary cesarean sections. Molding of the vertex and engagement itself often occur only after a real test of labor, which may terminate in delivery, or all too often in dystocia, and finally cesarean section performed so late that the risk should not have been taken.

Trial or Test of Labor.   At the end of pregnancy, or the beginning of labor, it is often impossible to know whether delivery can occur through the natural channel or not, without the risk of serious injury to the child. A trial of labor is necessary in cases in which disproportion is not great or the available evidence indicates a borderline contracted pelvis. Obstetricians are not of one opinion as to what this trial of labor should be. Whether labor should be allowed to continue long enough to be a real test of the ability of the fetal head to mold and engage in the contracted pelvis is a serious question. The risk associated with a test of labor should not be taken if there is reasonable doubt of pelvic delivery. A difficult second stage with forceps delivery and injury to the soft parts, or with fetal mortality or morbidity, is undesirable. With definite disproportion, trial only should be permitted. It is suggested that this consist of about six hours of fairly active labor, after the regular first stage pains have been established. Overriding or lack of engagement may then be noted by abdominal palpation. Vaginal examination should be avoided, but if the membranes are still intact it may be done if necessary. When the diagonal conjugate is between 9.5 and 10.5 cm., this trial should be sufficient.

If the diagonal conjugate is between 10.5 and 11.5 cm., trial of labor may be allowed to continue as a real test for as long as two hours in the second stage. The endocrinologic and psychic status of

the patient, character of the soft parts, type of labor, size and consistency of the fetal head and presentation and position of the fetus must be given due weight. The experience of the obstetrician is without doubt the most important single factor in assessing the indications and clinical progress of either trial or test of labor.

ANTEPARTUM HEMORRHAGE

Placenta Previa. The first bleeding of placenta previa may be anything from slight spotting to sudden profuse hemorrhage quickly followed by symptoms of shock. Since hemorrhage will surely recur, expectant treatment invites disaster. The patient should be sent to the hospital at the time of her first hemorrhage. The vagina should not be packed, as the pack is commonly ineffective; it introduces infection, and prohibits cesarean section, the treatment of choice for certain cases. Nor should a rectal examination be made, as it may precipitate serious bleeding and generally yields but little information. Even vaginal examination should be carefully considered. Certainly it should not be made at home, nor in the hospital until a suitable donor is on hand and preparations for delivery have been completed. It may not be necessary if a clear history and other important data indicate placenta previa, and that the patient should be delivered by cesarean section.

Successful treatment depends primarily upon the condition of the patient and the good judgment of the obstetrician. Parity, the character of the cervix, the amount of placental tissue in the birth canal, the duration of the pregnancy and the size and viability of the fetus must all be considered. The condition of the cervix is more important than the degree of placenta previa. It must be recognized of course that a high fetal death rate is inevitable since the fetus suffers from anoxemia or actual anemia if placental separation is considerable. Further, many babies are not viable or barely so, and the premature fetus, though viable, is a poor subject for vaginal manipulation of any kind.

Abdominal delivery gives the baby the best chance for survival yet it often increases maternal risk. It is contraindicated if the fetus is not clearly viable, or if vaginal packing or manipulation of any kind has been carried out, other than a careful vaginal examination made in the operating room just prior to operation. When the baby is not viable or dead, or all but dead as indicated by the character of the fetal heart, other methods of treatment are indicated.

Cesarean section is best for all patients who have had exsangui-nating hemorrhage, except when it appears that simple rupture of the membranes will be sufficient. There is general agreement that cesarean section, as a rule, is the best method of delivery in cases of central placenta previa, and in primiparae near term when the cervical os is partially covered by placenta. It is our own practice to perform lower segment cesarean section in all cases not definitely known to be marginal when the cervix is long or uneffaced, the baby viable, and the patient is not in labor.

Delivery by cesarean section reduces blood loss and hemorrhage can be more certainly controlled. If the operation is performed through the lower segment, the placental site may be packed and active bleeding from large sinuses may be stopped by suture. Infection, in the absence of vaginal pack or manipulation, is minimized. Fetal mortality will be definitely reduced, if the nonviable fetus is not given undue value.

Ablatio Placentae.   The result of treatment depends largely upon whether hemorrhage is frank or concealed, and the amount of blood loss. The importance of blood transfusion is obvious. In serious cases, Stander[92] believes that cesarean section should be performed if the patient is not in labor, and the uterus retained or removed "according as it contracts satisfactorily or remains atonic; the same applies even if labor is already in progress, unless the cervix is partially dilated and an early vaginal delivery may be expected."

There is a broad indication for delivery just as in eclampsia in which the method of delivery is equally important; yet as in eclampsia, the condition of the patient is more important, and mortality may be actually due to treatment. The fetal mortality is notable, and with it comes the implication that the child should be disregarded in selecting the type of treatment. However, this is no more true in ablatio than it is in placenta previa. Certainly, if the baby is alive and viable, and delivery can not be effected speedily from below, abdominal section should be performed if the patient's condition will permit.

Actually few patients need cesarean section and certainly not those already in severe shock, nor those threatened with the uremia or anuria of chronic nephritis. If cesarean section is performed, it should be the lower segment operation under local anesthesia. Uteroplacental apoplexy can not be diagnosed without opening

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the abdomen. Though accidental hemorrhage does predispose to postpartum bleeding, hysterectomy should be performed only for persistent hemorrhage. The Couvelaire uterus of itself is not an indication for hysterectomy.

Most cases, even severe ones, properly fortified by adequate transfusion, will do best with conservative treatment. Irving's[19] impressive experience with radical and conservative methods of treatment confirms this opinion.

Pelvic Tumor. Fibroids should not be removed during pregnancy. Though degeneration of a tumor may from time to time give rise to severe pain, often accompanied by leucocytosis, elevated temperature, localized tenderness and signs of peritonitis, these symptoms will subside under conservative therapy and neither myomectomy nor cesarean section are indicated. Occasionally, if the tumor is pedunculated, torsion may occur, and myomectomy will then become necessary.

Tumors of the uterus may seriously complicate labor or so obstruct the pelvis that delivery from below is impossible. In the vast majority of cases, however, they do not. Fibroids which, from their size and location, appear to create a real problem often rise from the pelvis in the latter weeks of pregnancy or even after labor has begun. Decision as to cesarean section should be reserved until then, and the patient given a trial of labor, not a real test, for the risk increases rapidly. In the majority of cases in which the tumor is found in the pelvis at the onset of labor, cesarean section is indicated. The large posterior cervical fibroid is the most dangerous, as it is least likely to rise out of the pelvis during labor. Dystocia or subsequent lochiastasis commonly result.

Multiple fibroids, or a large solitary tumor in the fundus of the uterus may be the cause of poor labor and slow dilatation of the cervix. Generally within a few hours it will be possible to note whether descent of the presenting part is progressing or not. If labor is good, and descent steady, labor should be allowed to continue without intervention, for pelvic delivery is safer; and operation for the fibroids, if indicated, is better done after involution has been completed. If cesarean section is elected, the question of hysterectomy or myomectomy always arises, and is not too readily answered. It is clear that myomectomy, unless for a pedunculated growth, carries with it considerable risk arising from hemorrhage and proximity of the myomectomy field to the bacteria laden cavity of

the uterus. Removal of multiple fibroids should not be considered at this time. Hysterectomy is a much safer operation, and smoother convalescence may be expected than after simple cesarean section. Hysterectomy should be performed, however, only after full consideration has been given to the number and location of the tumors, their probable effect on uterine drainage, the risk of postpartum hemorrhage and subsequent sterility.

Ovarian tumors are serious complications of pregnancy, labor and the puerperium. Torsion of the pedicle with rupture of the tumor due to twist or pressure may cause death. During pregnancy they should be removed as soon as possible after the third month. If found during the puerperium, laparotomy should be performed at once. If discovered first during the course of labor, the abdomen should be opened for removal of the tumor, and the patient allowed to deliver herself, if no other cause for dystocia is present. If found late in labor interfering with descent of the presenting part, no attempt should be made to push the tumor out of the pelvis as it may rupture; and on no account should the fetus be drawn past the tumor by forceps or traction on the feet. The abdomen should be opened, the tumor removed as quickly and as gently as possible, and delivery completed from below in the best way possible.

Occasionally, carcinoma of the cervix becomes a proper indication for cesarean section. Advanced disease forbids vaginal delivery with its associated laceration and hemorrhage. Cesarean section is performed purely in the interests of the baby, after every effort has been made to carry it to viability, the time of election depending upon the general physical condition of the patient. Since the danger of spread of cervical infection to the body of the uterus is a real one, hysterectomy with careful peritonealization of the cervix should follow cesarean section whenever it is feasible. This procedure appears to be safer than total hysterectomy.

Rarely neoplasms of the vagina or bony pelvis, or tumors not connected with the generative organs, as kidney, spleen, bladder or rectum make cesarean section necessary.

Abnormal Presentation. Clearly the presentation and position of the fetus must receive thoughtful consideration in every case in which vaginal delivery is in doubt, yet cesarean section is not warranted for these indications alone. Nor is the expectation of long labor a proper indication. Slight increase in fetal risk does not justify the risk of cesarean section, yet this risk may be properly assumed by

the patient when her age makes the probability of another pregnancy unlikely.

Transverse presentation in the primipara is sufficient to indicate pelvic contraction. Cesarean section is indicated, since pelvic delivery is always operative, and commonly associated with serious injury to the maternal soft parts and fetal morbidity and mortality as well. It is not an indication for cesarean section in multiparas with good obstetric history. Cesarean section is better than version or decapitation for an impacted shoulder, when the mother and baby are in good condition. The danger of fatal peritonitis is great, yet the risk compares favorably with other methods of treatment and cesarean section gives the baby its best chance for survival. Hysterectomy is generally indicated.

Presentation of face or brow in the primipara is likewise an indication of contracted pelvis or cephalopelvic disproportion. It is important to remember that the association of fetal malformations is as high as 10 per cent. Cesarean section is indicated for the same reasons as in transverse presentation. If, with intact membranes, progress is steady, a fair test may be advisable, depending upon the size of the baby and the character of the labor. If progress is not made, and this is most likely in posterior positions, a careful vaginal examination will indicate the course to be followed. If rupture of the membranes occurs with a posterior face presentation, an immediate attempt at conversion to a vertex or rotation to an anterior face should be made, if abdominal delivery is not indicated.

Breech presentation in the primipara implies considerable fetal mortality, yet of itself it is not an indication for cesarean section. Prophylactic version in the antepartum period is recommended. Unengagement of the breech before labor begins is of no importance. In the absence of pelvic dystocia good labor will accomplish delivery. With a large fetus in frank breech presentation and minor pelvic contraction the patient's age may properly be taken into consideration.

Postoperative Dystocia. The end results of previous pelvic surgery may cause dystocia, but as a rule the circulatory changes of pregnancy bring about softening and relaxation of tissues sufficient to allow pelvic delivery. Rigidity of the soft parts is rarely so great that it cannot be overcome by the advance of the presenting part.

Extensive cicatrices of the vagina following repair of vesicovaginal or rectovaginal fistulas make elective cesarean advisable. Previous perineorrhaphy, however, or even plastic repair of a third

degree tear, unless the rectal repair was high, may be adequately protected during pelvic delivery.

Prior amputation of the cervix, or deep cauterization may result in scar formation so dense that rupture of the uterus may occur during labor. Partial amputation of the cervix as in the Manchester-Fothergill operation for prolapse of the uterus should not interfere with pelvic delivery.[30] In any event, trial of labor is advised, with careful observation of the progress of cervical dilatation. In the absence of previous operative procedures there can be no true cervical stenosis. Histologic examination of cervices from patients in whom dilatation occurred slowly has shown no significant structural alteration. Without question uterine inertia is the cause, and cervical stenosis has now ceased to be a common indication for cesarean section.

Fixation of the fundus of the uterus to the abdominal wall may so distort the birth canal, that delivery, unless by cesarean section, is impossible. Trial of labor is indicated, however, and should be prolonged in those cases in which the cervix is not displaced posteriorly and when its axis is in relation to the parturient axis.

Previous myomectomy is a competent cause for rupture of the uterus, yet cesarean section is not always indicated. If the operation had been performed for a pedunculated fibroid, or a tumor near the isthmus or cervix, or if the cavity of the uterus had not been widely opened, pelvic delivery is advised. After multiple myomectomy, as a rule, cesarean section should be elected. The size and number of the myomas excised, the depth and sites of uterine incisions, the occurrence of postoperative morbidity and the care with which the uterine wounds have been sutured are of importance. It would be wise for the gynecologist who performs a myomectomy on a patient in the child-bearing age to record these data on the patient's chart, with his opinion as to whether cesarean section is advisable in future pregnancies.

Fetal Indication. A great many unnecessary cesarean sections are performed in the interests of the child. Intervention occurs particularly for uterine inertia or after a trial of labor, too long or perhaps too short, or when dilatation of the cervix has been slow. It is true that any complication of labor in which pelvic delivery gravely threatens the life of the child may be a valid indication for cesarean section, but not when the maternal risk is excessive or the baby's chance for survival not good.

Prolapse of the cord or forelying cord is a generally accepted indication in the primipara with a viable baby. If the cord lies outside the vulva, it should not be pulled through the uterine incision, but cut close to the placenta and delivered from below, though this may not often be feasible.

Habitual death of the fetus before labor begins is a good reason for cesarean section. One previous stillbirth with a history of normal or even difficult labor is not a valid indication. After close inquiry into the facts and circumstances of the previous pregnancy and delivery and careful antepartum examination, pelvic delivery may often be awaited with confidence. In any event, a trial of labor is indicated. A history of two or more stillbirths is sufficient reason in most instances for elective cesarean.

The old primipara may be properly considered here. Occasionally, labor may be surprisingly short, yet on the whole the duration of labor does increase with age. However, the incidence of cesarean section should not increase with age alone. When a trial of labor shows that labor will be protracted and the patient may lose the only baby she may ever have, cesarean section is indicated.

Excessive size of the child, particularly when associated with prolonged postmaturity may cause serious dystocia. If, after trial of labor, the head is not engaged, cesarean section is warranted.

Previous Cesarean Section. The nature of the reparative processes in the uterine wound is of considerable importance in the decision to elect another section. Kerr[54] states that Couvelaire, Gamble and McIntyre have shown that the wound heals by fibrous tissue replacement of muscle fibers. Schwartz, Paddock and Bortnick[56] found that healing takes place chiefly by proliferation of fibroblasts in the spaces between the muscle bundles. Stander[92] believes that the uterus, like all other organs made up of nonstriated muscle heals by regeneration of muscle fibers, not by scar tissue, and that in the absence of infection, and with proper suturing the risk of rupture is minimal.

Kerr[54] contends that no matter how carefully the upper segment has been sutured the risk of rupture is always present for these reasons: (1) The wound is very apt to become infected; (2) the involuting muscle fibers are degenerating; (3) the wound area is in a state of unrest especially for the first twenty-four hours, with sutures loosening and gaping a little; (4) the sutures necessarily function for both coaptation and hemostasis, yet the muscle fibers are irregularly

distributed and exact approximation is difficult, so that blood pools here and there, to be replaced by fibrous tissue later; (5) since the placenta occurs on the anterior wall in 40 per cent of the cases, it is difficult to make wound edges meet exactly, because the undermost part is friable due to the presence of large sinuses; this favors gutter formation with weakness of the scar and hernia of the membranes into it in late pregnancy; and (6) if in later pregnancy the placenta forms over this scar, destructive action of the trophoblast on fibrous tissue favors rupture.

In a certain percentage of cases rupture will occur during pregnancy or labor. Symptoms are often slight, and the patient may not die from hemorrhage or sepsis, but the child is usually lost. It is very likely that rupture occurs in the upper segment more often than in the lower. Holland,[44] in the first collective study of ruptured scars, found 4 per cent of ruptures after the classical operation. Wetterwald,[98] in 1926, in 3,600 lower segment operations, and Gelle,[27] in 1932, again collecting all available cases reported approximately the same percentage of rupture, 0.25 per cent.

Irving[48] reporting their experience at the Boston Lying-In Hospital, states that from 1929 to 1938, fifty-five women who had had previous cesarean sections were delivered pelvically seventy-three times, one patient five times. If the operation had been performed in their hospital for a temporary indication they "are disposed to allow labor under careful supervision; otherwise cesarean section is repeated." Lazard,[55] however—and we know of similar cases—saw a patient who had three difficult pelvic deliveries after she had been sectioned in her second pregnancy for an overlarge fetus, die in her sixth pregnancy before she could be operated upon for complete rupture of the old cesarean scar. "Once a cesarean always a cesarean" if rigidly followed as a dictum results in a steadily increasing number of cesarean sections, with increased risk in secondary operations. In 1938, Fraser and Sparling[26] in their series found 21.9 per cent were for previous cesarean section; in 1927, the percentage was but 12, whereas in 1936 it had risen to 34. Daily,[14] in 1939, analyzing 1,000 consecutive cesarean sections at the Chicago Lying-in found that 27.9 per cent had been sectioned before. Matthews and Acken[61] in a critical survey of 1,066 cesarean sections found a greater incidence of sepsis and poorer results in repeated operations, with all the mortality in the classical group.

[13]

For the most part obstetricians are of the opinion that a carefully supervised trial labor is reasonably safe if the indication for the previous cesarean section is not present and the postpartum course had been normal. This is particularly true of the lower segment operation. If labor has begun and satisfactory progress is being made, careful observation and pelvic delivery aided by forceps is the treatment of choice. Some disagree completely with this point of view, and others seek a compromise. Plass,[76] for instance, thinks that if the first operation was performed while the patient was still a primagravida, and not in labor, it is unwise to risk vaginal delivery; but if the operation had been performed on a parous woman for some complication, pelvic delivery would be more reasonable and frequently conducted safely.

It should not be forgotten that rupture of the uterus is a very real danger, not to be discounted. Afebrile convalescence is no guarantee of a scar that will not rupture. No recent statistics on this important subject have been published, yet there is increasing evidence that the dictum, "once a cesarean, always a cesarean," must be modified.

The following factors must be weighed in arriving at a decision:

1. *The Type of Previous Section.* It is certain that the scar following the classical operation is more likely to yield than that following the lower segment operation. A vertical incision in the lower segment is likely to give rise to a weaker scar than the transverse incision because of the almost constant inclusion of part of the corpus uteri in its upper end. When rupture does occur after the lower segment operation with vertical incision, it can generally be demonstrated that the upper end of the scar yielded first.

2. *The Presence of Previous Postoperative Morbidity.* If infection of the uterine incision has occurred in a previous section, firm healing of the scar is interfered with and a weaker scar results. Even though a febrile puerperium cannot be shown to be due to uterine infection, the existence of a weak scar should be assumed.

3. *The Occurrence of Previous Infravaginal Delivery.* If all previous deliveries, one or more, have been by cesarean section, so that no previous preparation of the lower birth passages has ever occurred, the strain on the uterine scar during the second stage of labor is likely to be increased.

It would appear that there is little reason for cesarean section under the following circumstances: A multipara who has had at least one spontaneous delivery of a normal sized living child without

protracted labor, who has also had a previous lower segment cesarean section with transverse incision without postoperative morbidity and in whom the indication for the previous section is not present.

It is not safe, however, under any circumstances to risk infravaginal delivery after previous cesarean section unless the patient is carefully observed for signs of uterine rupture during her entire labor in an institution at which facilities for immediate cesarean section and blood transfusion are available.

MEDICAL COMPLICATIONS

Cardiac Disease. Women with cardiac disease are not good risks for parturition, yet it does not follow that cesarean section is indicated. In fact, unless there is definite evidence of major damage to the heart, cesarean section should not be performed for cardiac disease alone. Patients with heart disease, except those who are clearly bad risks, do well in labor, if the first stage is conducted under morphine analgesia, and delivery by forceps effected promptly in the second stage under local anesthesia. If dystocia develops early in labor, cesarean section should be more seriously considered. Disproportion and poor labor are of course important factors in judgment.

In general, when it appears that cardiac reserve is so low that the patient might not survive a comparatively easy labor, cesarean section should be elected as near term as possible. Local anesthesia is best, and open drop ether next in safety. Other anesthetics are more dangerous.

Operation should be performed only after the patient has been made a reasonably safe risk. It is certain that the actual load of pregnancy on the circulation does not increase progressively with the months of gestation. Failure is commonest, it is true, in the last trimester, yet clinical improvement may be confidently expected in the last few weeks before term. It is of the utmost importance that this optimum time be awaited. Hamilton[36] has shown this very clearly, and our experience over a five-year period with a large number of well supervised cardiac patients is the same.

Hamilton points out, too, that infant mortality is very high if delivery occurs before the last two or three weeks. After eliminating the very bad risks in all his cases of pregnancy with evidence of serious heart damage, he found that five patients in his first 750 died of puerperal sepsis, one in 600 deliveries from below, and four in 150 delivered by abdominal hysterectomy. Whether women with cardiac

[15]

disease have increased susceptibility to .infection after cesarean section is not certain, yet this added risk must be given due weight.

Tuberculosis.   Consideration of cesarean section as a method of delivering tuberculous women depends largely upon the presence of exudative or pneumonic tissue reactions. The extent of involvement of the lungs is of less importance. With proper treatment the productive fibroid lesion may even improve during pregnancy, and parturition may present no major problem in the absence of long labor, hemorrhage or infection. On the other hand the labile pulmonary lesion,· however small, is a serious complication of pregnancy, and women with active lesions should spend their entire antepartum period in the hospital under the care of the internist and obstetrician.

Since it appears that a comparatively short labor carries with it less risk than cesarean section, the method of delivery should not be definitely selected in any case until term, or after trial of labor. Disproportion, early rupture of the membranes, and dystocia due to soft part interference or abnormal presentation assume increased importance. In women with healed lesions, or those in whom tuberculosis has been inactive for some time, cesarean section need not be considered. Shortening of the second stage of labor by forceps delivery under local anesthesia is usually advisable. Prolonged rest with artificial pneumothorax and other forms of modern tuberculosis therapy postpartum are important, whether cesarean section has been performed or not.

Diabetes Mellitus.   It is clear that certain diabetics had best be delivered by cesarean section. Selection of such cases is often so difficult that only when maternal or fetal death has occurred after pelvic delivery does it become obvious that cesarean section should have been elected. Indications for cesarean section may be maternal or fetal, or both. The fetal indication is at present not only the most usual, but is held by some to be the only one.[66]

Maternal Indication.   With the introduction of insulin the incidence of pregnancy in diabetic women has materially increased, and the problem of the proper care of the juvenile diabetic is more often encountered. These patients run the greatest risk in parturition. The diabetic who is permitted to go into labor must be observed carefully, preferably by an internist, and particularly when labor is prolonged. Early exhaustion of glycogen reserve may produce hypoglycemia; and starvation, vomiting and anesthesia may produce

ketosis. Proper insulin dosage during labor is difficult to determine and hourly estimation of the blood sugar may be necessary in severe cases. Two important co-efficients must be considered before electing cesarean section in the interest of the mother:

1. *The Diabetic Factor.* The juvenile or severe diabetic is most difficult to treat safely during labor, since she may die of diabetes even though the obstetrician be assisted by the most expert internist. The nonjuvenile or nonsevere diabetic may generally be allowed to deliver infravaginally under local anesthesia.

2. *The Obstetric Factor.* Expectation of prolonged or difficult labor should aid in the election of cesarean section. Thus the primipara with juvenile diabetes and late engagement of the head at term, is best managed by cesarean section, while pelvic delivery is indicated in a multipara with nonjuvenile diabetes, and no other obstetric complication.

The Fetal Indication. Fetal mortality in diabetics, estimated recently as high as 40 per cent, is due principally to intrauterine death during the last few weeks of pregnancy.[78] Joslin[50] has shown that stillbirths occur three to six times as frequently in the diabetic as in the nondiabetic. Overgrowth of the fetus often precedes death. White and Hunt[100] are able to predict premature delivery, stillbirths and neonatal deaths by an abnormal rise of the chorionic gonadotropin after the twentieth week to a level of 200 rat units, and claim that these accidents can be prevented by administration of huge amounts of estrogen and progesterone, too large at the present time to be available to the general profession.

Cesarean section two to four weeks before term is advised by some authorities in an effort to ensure safe delivery of a viable fetus. Determination of the proper time may be supported by the use of the *x*-ray. Suprapubic delivery is indicated when the fetus is abnormally large or further opportunity for pregnancy is unlikely. If laboratory facilities are available for demonstrating abnormal hormonal behavior, prediction of intrauterine death should aid in the election of cesarean section. Since infants of mothers with diabetes mellitus show a high mortality rate, especial care must be given the baby after delivery or the purpose of the operation will be defeated.[90]

In any case both maternal and fetal indications must be considered jointly. It would appear that cesarean section is indicated in the primipara with severe diabetes since childhood, when prolonged labor is likely.

Other Indications. Cases of pelvic exostoses, bony tumors, healed fractures of the pelvic bones, ankylosis of the hip, spondylyolisthesis, osteomalacia and kyphosis are not of themselves indications for cesarean section. They necessitate expert pelvic roentgenography before a decision can be made. Previous spontaneous labor may have occurred, yet section may be indicated in a subsequent pregnancy.

Uterus bicornis or didelphys is generally not a cause for dystocia though the nonpregnant horn or uterus may block the birth canal and necessitate suprapubic delivery. Cesarean section may also be indicated in cases in which postpartum lochiastasis with subsequent puerperal sepsis is anticipated. When section is done for this indication, either the pregnant or nonpregnant horn or uterus should be excised. The latter procedure is recommended.

Hypopituitarism with the dystrophia dystocia syndrome of DeLee may be a proper indication for abdominal delivery when associated with severe uterine inertia or primiparity late in life.

Postmortem cesarean section, according to Stander[92] is not recommended, since it is usually unsuccessful in saving the life of the baby and because of the "abhorrence in which it is more or less justly held by the laity." However, others are of the opinion that the physician is morally obligated to try to save the life of the child after the death of the mother. Twins have been saved this way.[38] DeLee[16] approves of this procedure and says "It is not even necessary to obtain the consent of the husband or the family, though for his own protection, the accoucheur should get it if possible."

CONTRAINDICATIONS

In the absence of a definite indication, abdominal delivery should not be considered. Cesarean section is a major operation with unparalleled risk of excessive hemorrhage, postoperative shock and peritonitis. It is so dangerous that those who are not competent to weigh the relative merits and disadvantages of pelvic and abdominal delivery in a given case, no matter how capable they may be as operators, should not feel called upon to perform the operation. To attempt the operation in poor surroundings and without adequate assistance is to court disaster.

Cesarean section is generally contraindicated when the fetus is known to be dead, unless no other method of delivery is feasible or as safe. When cesarean section is done for fetal indication, the risk should not be taken if the chances of survival of the baby are not

thought to be good. Nor is cesarean section justifiable for the sake of the baby, when maternal death would appear to be a probable result of this procedure.

Actual infection is a contraindication. Ideally, there should be no suspicion of infection, no long labor or exhaustion, no attempt at induction of labor or delivery and no concurrent febrile disease. The fundamental prerequisites for the success of any laparotomy have increased importance in abdominal delivery. Cesarean section may be elected because of greater danger from the alternative treatment, yet the outcome becomes more and more doubtful when any of these contraindications are disregarded.

In the presence of exsanguination, exhaustion and acidosis, cesarean section is contraindicated until the patient is properly prepared for operation.

Every vaginal examination increases the risk. Pathogenic organisms may be present without febrile reaction. Patients who have been subjected to repeated vaginal examination, even when made under carefully controlled conditions, are very poor risks.

Rupture of the membranes for more than a few hours invites infection of the amniotic sac and the uterine cavity. Invasion of the placental bed by virulent organisms may be responsible for death of the baby a few days later.

Induction by catheter or bag, no matter how expert the operator or how scrupulous his technic, prohibits cesarean section. Attempts at forceps delivery or version are even worse.

Acute and chronic nephritis contraindicate cesarean section, yet at times compromises must be made.

The operation should not be performed for the purpose of interrupting pregnancy during the last trimester, or to accomplish sterilization. And, as a matter of fact, the risk should never be taken simply to sterilize a patient who is capable of vaginal delivery.

In eclampsia, cesarean section is definitely contraindicated. In Brooklyn[32] from 1921 to 1926, the mortality of cesarean section for eclampsia was 26 per cent in 104 cases, and in New Orleans[70] for the same period 41.5 per cent in forty-one cases. In 1940, King[56] comparing two cesarean section surveys carried on in New Orleans showed a reduction in the maternal death rate from 16.1 in the first period (1921 to 1926) to 5.9 per cent in the second (1926–1936). This notable reduction was largely due to the partial elimination of eclampsia as an indication for cesarean section. There are no modern

statistics which justify the performance of cesarean section after the onset of convulsions.

If cesarean section should be performed for pre-eclampsia, great care and good judgment will be necessary in the selection of cases, else the mortality will be high. The patient must not be in labor. In fulminating cases the operation may precipitate the convulsive seizures that we wished to avert. When all other methods of treatment have failed to bring about improvement in the patient's condition, or when she grows worse in spite of treatment, there is an occasional indication for cesarean section in the primigravida with an intact cervix near term and not in labor. On no account should the operation be performed under general anesthesia. Local anesthesia should be chosen.

PREPARATION FOR OPERATION

Preoperative care for cesarean section includes the usual preparation for laparotomy as well as operative delivery. In elective section it is well to have the patient admitted to the hospital a few days prior to operation. General physical examination is necessary and careful observation for respiratory infection is important. She should have previously been warned against the dangers of douches and coitus during the last month of pregnancy.

Roentgenography is an additional safeguard in the occasional case in which gross malformation such as anencephalus, hydrocephalus or spina bifida are unsuspected. If the operation is to be performed chiefly in the interests of the baby, these malformations are of great importance. Occasionally, twins or prematurity may be diagnosed in this way when clinical data are uncertain, and plans for cesarean section as well as the time of operation may be influenced.

On the day before operation the abdominal and pubic areas should be shaved, the skin washed thoroughly with soap and water and sterile dressings loosely applied to the abdomen. In the operating room, a wide operative field from breasts to thighs, paying special attention to the entire mons veneris may be sponged with ether, and lightly painted with one of the newer antiseptics. In elective section an enema should be given on the day before operation, but no cathartic; no other enema is necessary or advisable.

Immediate preoperative medication may include only atropin gr. $\frac{1}{150}$. Morphine is not without danger for the baby. Pituitrin,

ergonovine, and morphine for hypodermic use should be quickly available during the operation.

Precaution should be taken to ensure an empty bladder at the time of operation. The catheter should be left in place, and open if desired. If care is not taken, the partially filled bladder may make exposure of the lower segment difficult; or it may be inadvertantly incised when the abdomen is opened. Bladder injuries during the lower segment operation occasionally occur and are largely due to neglect of this precaution.

Final auscultation of the fetal heart should be performed in the operating room, since fetal death will usually make cesarean section unnecessary. If the heart sounds had previously been easily heard, their absence is good evidence of fetal death.

The operating room itself is of great importance. If a series of operations are to be performed in the same room, cesarean section should be scheduled first. Section should never be performed in a room just previously contaminated by another operative procedure. Proper masks covering nose and mouth of everyone in the operating room including the anesthetist are of vital importance. Those with respiratory or skin infections should not be permitted to enter the room, unless they have been shown by bacteriological cultures to be innocuous.

The obstetrician will need three assistants and two nurses at the operation. It is the sole function of one assistant, who has been trained in management of birth apnea, to take care of the baby. Resuscitation apparatus, oxygen and warm blankets should be available. A special table should have on it a tracheal catheter, cord tie, sterile dressings, 1 per cent silver nitrate, clamps and scissors. The second assistant will manage retractors and the second nurse will circulate.

Preoperative vaginal instillation of antiseptics like 3 or 4 per cent mercurochrome or 1 per cent neutral acriflavine in glycerine have been advocated. Brown,[9] in a series of 144 cesarean sections demonstrated that antiseptic vaginal instillations definitely lowered the incidence of morbidity and mortality. Since our own figures for febrile morbidity and mortality have been very low without their use, we do not believe that this procedure is necessary.

Trendelenburg position is very helpful in keeping intestines out of the operative field and making the lower segment more accessible. When infection is suspected, however, the head of the operating

[21]

table should be lowered no more than is actually necessary for this purpose, or it will become more difficult to prevent infected amniotic fluid from reaching the upper portion of the abdomen.

If cesarean section is to be performed soon after admission to the hospital for an urgent indication, great care should be taken to discover whether the stomach is empty or not. If the patient has had a meal shortly before, a stomach tube should be quickly passed and the stomach emptied. This is important, whether general or local anesthesia is planned, and it is absolutely essential if a general anesthetic is to be administered. Death from vomiting and aspiration of stomach contents during general anesthesia is not uncommon.

BLOOD TRANSFUSION

Because of the ever present danger of hemorrhage during the course of cesarean section or immediately afterward, full preparation for blood transfusion should be made prior to operation. After typing and crossmatching, a suitable donor should remain in the hospital until the operation is completed and the patient safely back in her bed. If a blood bank is available, similar preparations regarding the accessibility of compatible blood should be made. In any case, institutions where cesarean sections are performed should at least have blood plasma or serum available since these are now easily procured and may be kept safely for long periods of time.

Adequate replacement of blood loss during cesarean section and the treatment of shock are of great importance. Analysis of deaths following cesarean section show that hemorrhage and shock contribute heavily to the mortality; and, in sepsis, the most common cause of death, the anemia resulting from hemorrhage is often a strong predisposing factor.

As a result of recent work on the functional and structural changes following hemorrhage and shock, we can now more fully appreciate the great importance of speedy and adequate replacement of blood loss.[69] It has been shown that the use of intravenous crystalloid solutions such as dextrose and saline dextrose have only a temporary therapeutic effect. In shock they increase blood volume for a short time only, quickly diffusing through abnormally permeable capillaries.[60]

When hemorrhage is serious there is no question but that transfusion of whole blood is best. However, delay in securing compatible blood may be sufficient to allow for irreversible changes in

the capillary bed so that when finally given it may be too late to save the patient. When a blood donor is used, a delay of two to four hours is not unusual. The many benefits that a large hospital may derive from a blood bank are already well known but even there the interval of time elapsing between the call for blood and the transfusion averages about forty minutes.

The answer to the problem lies in the use of blood plasma or serum. Collection and administration of blood plasma are simple, requiring no complicated apparatus. Blood may be drawn into a vacuum flask containing anticoagulant such as sodium citrate, and allowed to stand in the refrigerator until the plasma has separated. The supernatant plasma is then aspirated into another vacuum flask containing a quantity of saline equal to the volume of plasma introduced. The addition of the saline solution tends to keep the plasma in solution.[57]

No typing or crossmatching of the plasma is necessary[13,8,21,93,97] and there are reports in the literature which indicate the absence of harmful reactions.[2,39] There is evidence to indicate that it is best to pool plasma for adsorption of agglutinins.[40]

There is no reason why even the smallest hospital should not have blood plasma immediately available for use in the operating room. Should an institution be unable for some reason to collect its own blood plasma, it can be secured commercially at reasonable cost in fluid or powder form. The intravenous use of blood plasma is ideal in the treatment of shock not accompanied by severe hemorrhage, since in these cases it is depletion of plasma that must be combated. Actually, hemoconcentration may contraindicate the use of blood. In the case of severe hemorrhage, plasma should be given during the usual delay that accompanies preparation for transfusion of blood.

ANESTHESIA

Many methods of anesthesia have been used. When surgical risk is normal, general anesthesia is satisfactory in that it ensures adequate relaxation and dispels the patient's fear of operation. However, a general anesthetic of any type is a dangerous and profoundly toxic drug and great care must be taken in its administration. Further, it may not be given to women with upper respiratory complications, cardiac disease, tuberculosis or toxemia; and the margin of safety is small when hemorrhage has been considerable or the patient has been long in labor. All inhalation anesthetics pass

through the placenta to the fetus and may make resuscitation difficult.

Ether causes a notable increase in relaxation of the uterus, just before and for a few hours after removal of the placenta, and atonic hemorrhage is common. In our experience it causes more bleeding than any other type of anesthetic. Firm uterine contraction is delayed, placental separation unduly prolonged and blood loss may prove fatal.

Nitrous oxide produces analgesia by a steadily increasing anoxia. Since anesthesia is possible only when concentration approaches 100 per cent, the danger to the fetus is obvious. When used in the induction of anesthesia and preceding the administration of ether, the obstetrician must be vigilant lest it be used with less than 25 per cent oxygen, for stillbirth, or neonatal death a few hours or a few days after delivery may be the direct result of its administration.

Ethylene is better than ether if local anesthesia has failed or can not be used for what appears to be good reason. Cyclopropane would seem to have few contraindications in obstetrics because of its ease of induction with an adequate oxygen supply and low toxicity. Relaxation is better than with ethylene and approaches that of ether. Since anesthesia is produced in concentrations even lower than 10 per cent, it is clearly very potent, and may produce untoward effects on mother or baby even though alveolar oxygen is adequate. Our present knowledge of its action on the circulatory system is so inadequate that its use in cesarean section for cardiac disease is highly debatable. Furthermore, anesthetic mixtures with cyclopropane are explosive.

Obstetricians with but few exceptions agree that spinal anesthesia in cesarean section is dangerous and carries the greatest risk of mortality from anesthesia. Yet it can not be denied that it has very definite advantages. Anesthesia is so deep and abdominal wall relaxation so profound that the operative procedure is simplified.

Cosgrove, Hall and Gleeson[11] have reported 244 cesarean sections performed under spinal anesthesia with no mortality attributable to the anesthetic, and believe that this series is large enough to refute statements that this method of anesthesia is dangerous in cesarean section. Arteriosclerosis, they say, is the only contraindication. The uterus contracts promptly, manual removal of the placenta is rarely necessary and delayed hemorrhage is uncommon; it is

probable, too, that its use is not harmful to the baby, all decided advantages.

However, it is generally agreed that the mortality directly due to its use is highest in pregnant women. It is likely that women at or near term are particularly vulnerable. DeLee,[18] a consistent objector to its use, states that since its dangers are so well known, no spinal anesthetic should be used in obstetrics. He believes that during labor the changes in blood pressure are marked, and that changes in intraspinal pressure are rapid and profound; sudden emptying of the uterus changes pressures and currents, and the resultant drop in blood pressure may be simultaneous with the fall due to the anesthetic. This is particularly dangerous if there is hemorrhage.

Marshall[61] in his excellent monograph on lower segment cesarean section quotes Franken[24] as collecting case reports of 2,000 cesareans performed by twenty operators, with fourteen deaths attributable to the spinal anesthetic alone. In Franken's own clinic 1,000 gynecological operations were performed safely under spinal anesthesia, yet the first patient with a cesarean section died. Marshall says that his own experience leaves him no doubt that spinal anesthesia is particularly dangerous in cesarean section, and that "Any obstetrician who sets out to perform a large series of cesarean sections under spinal anesthesia must be prepared to face a possible mortality of not less than one per cent due to this cause alone."

According to CoTui[12] it is the consensus of opinion that the action of the drug is more inconsistent than might be expected, and that the anesthetic level is unpredictable. He is sure that the physiological problem is not simple and can barely be outlined. Gravitational current, curvature of the spine, pulsations of intradural contents, fixation, destruction and absorption of the drug all need to be further studied.

Babcock[4] says that "The dangers of spinal anesthesia lie more in the user than in the drug. . . . Especially to be feared is the novice who does not know how to watch for and meet emergencies. . . . For spinal anesthesia to be safe, the anesthetist must constantly watch the patient during the anesthesia in order instantly to detect and combat conditions that presage arrest of respiration or circulation."

Since the great majority of authorities agree that spinal anesthesia is an exceedingly dangerous anesthetic for the obstetric patient, it is inadvisable for the occasional obstetric operator to

employ this method of anesthesia routinely. The attitude and experience of the general surgeon with the use of spinal anesthesia are of no value because the obstetric problem of abdominal delivery is in no way comparable to ordinary surgical problems. Secondary respiratory failure based on primary circulatory failure is the cause for death, and apparently pregnancy predisposes to this danger.

It is our opinion that rectal or intravenous anesthesia have no place in cesarean section.

Local anesthesia is the anesthetic of choice for cesarean section because it is safest for mother and baby. In DeLee's[15] clinic more than 1,500 cesareans have been performed under local anesthesia, with no death due to the anesthetic. There are no contraindications to local anesthesia but there are limitations. An extremely apprehensive or restless patient might better be operated upon under a general anesthetic; and in the presence of peritoneal adhesions, or when unusually extensive procedures requiring complete relaxation are planned, as in extraperitoneal section, a general anesthetic had best be used.

The only real argument against local anesthesia is whether or not one can obtain adequate anesthesia with this method. The fault is generally not with the anesthetic or procedure but with the operator. Its technic demands proper administration of the drug, patience in awaiting its full effect and the utmost gentleness in the handling of tissue. There need be no haste in the usual case.

The advantages of local anesthesia are: (1) Uterine atony, delayed placental separation and undue hemorrhage are rarely encountered. (2) There is little risk of narcosis of the baby from anesthesia. If morphine is not administered until one is ready to incise the uterus and extract the fetus, there is no risk at all. (3) The postoperative course of the patient will be considerably smoother. Vomiting, which may tear out peritoneal sutures is seldom seen. Pulmonary complications are rare. Abdominal distention and discomfort are minimal. (4) It is safe in constitutional diseases that contraindicate general anesthesia, as toxemia, cardiac disease and tuberculosis, and may be given with safety to patients with upper respiratory infections.

Technic of Local Anesthesia. A sterile solution of 300 cc. of 0.5 per cent novocain to which 1 cc. of a 1-1000 solution of adrenalin chloride may be added, is prepared. A hypodermic syringe with a fine needle for the initial wheal, two continuous flow syringes with

finger and thumb rings and two long flexible needles are the only special instruments required. A heavy pad for the operating table is a distinct advantage. The anesthetist should take her usual place
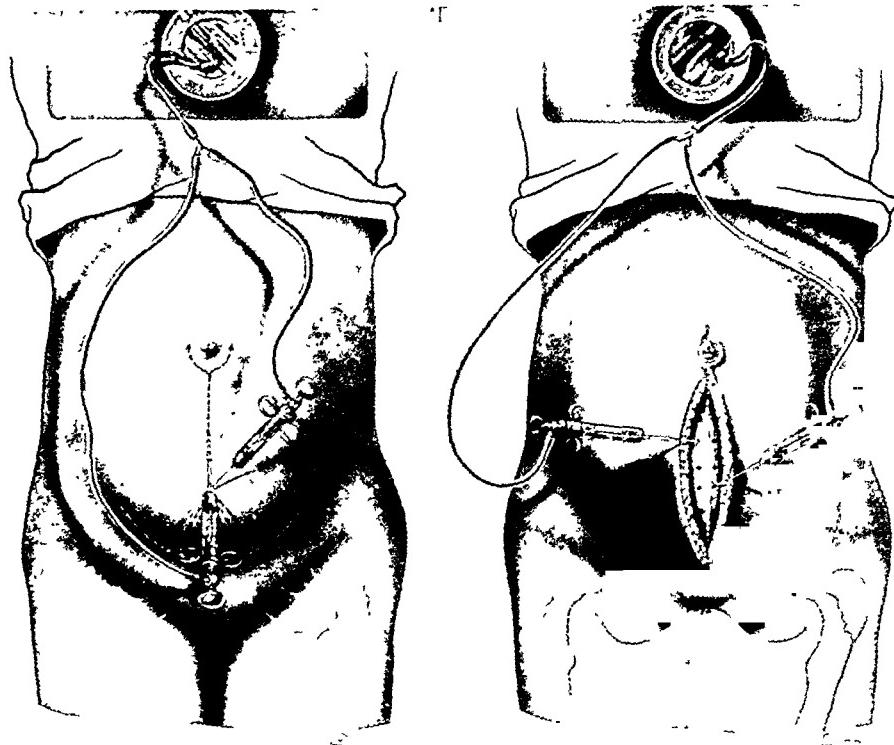
FIG. 1. Local infiltration for cesarean section. Two syringes may be used simultaneously by the surgeon and his first assistant. The basin of novocaine solution and the tubing allow for continuous infiltration. With one syringe the solution of novocaine is injected superiorly; with the other, inferiorly. Note the arrows indicating the fanning-out of the infiltration at the lower third of the mid-abdomen.

FIG. 2. Local infiltration for cesarean section. The syringes inject the solution of novocaine beneath the anterior sheath of the rectus fascia at the points marked by crosses, half way between the midline and the lateral edges of the wound. Note the fanning out of the infiltration at the lower one-third of the wound.

and may give the patient small sips of water or small pieces of cracked ice during the operation, and engage her in conversation.

The patient's eyes should be lightly covered, because of the glare of the operating room lights, but her ears should not be plugged as some advise, as the operator in whom she has confidence may

wish to reassure her from time to time. She should be informed when the operation has begun.

After a small wheal is raised with a fine hypodermic needle, novocain is injected in large amounts ahead of the advancing long needles, keeping close to the skin, raising a continuous wheal and infiltrating the tissues from the umbilicus to the symphysis in the midline. (Fig. 1.) Simultaneous injection from either side of the table by two operators saves time. Fanwise infiltration of the lower end of the incision in all its depth is of great importance, else necessary retraction will be impossible. Incision may be made with a sharp scalpel only when the operator is convinced that the procedure will be painless. When hemostasis has been carried out, the rectus sheath is filled with a large amount of novocain solution by piercing the aponeurosis at several points on either side of the linea alba. (Fig. 2.) As a rule the posterior rectus sheath and peritoneum will be anesthetized this way. This is better than infiltrating the aponeurosis and peritoneum separately, as the peritoneal infiltration with this method may make it difficult to see or palpate the bladder edge. Fanning out the lower area of infiltration into the aponeurosis is essential. The peritoneum is then opened and the vesico-uterine fold of peritoneum found. Retraction necessary for lower segment cesarean section will be readily possible. Sudden pulling on the retractors is improper since it will almost always cause the patient to have pain, and perhaps lose confidence in the effectiveness of the anesthesia. All movements with the retractors should be slow and deliberate. The visceral peritoneum need not be injected, nor is it necessary to flood it with novocain solution. The uterus may be opened and the baby extracted without pain if the incision is long enough. If difficulty is encountered in lower segment operation, brief inhalation of ethylene or nitrous oxide and oxygen will be necessary. Morphine ¼ gr. may be given shortly before delivery of the baby. Uterine suture and closure of the abdominal incision may be generally carried out without further local anesthesia if the operating time has not been excessive.

INCIDENTAL SURGERY

The addition of other operative procedures to the cesarean operation definitely tends to increase morbidity and mortality. Eisaman and Cook[22] analyzing 1,322 cases of cesarean section with forty deaths were astonished to find that 60 per cent of the women who died had additional operative procedures, while in only eight or 33

per cent of them infection was due to labor. Cesarean section is surgery enough.

Removal of the appendix is indefensible. The residual amniotic fluid and blood are excellent culture media for any bacteria liberated and contaminating the peritoneum. Further, the changing relations and unrest of the cecum during the postpartum period disturbs normal healing of the appendiceal stump. A fatal peritonitis may easily result from an incidental appendectomy under these conditions.

Sterilization alone is never a valid reason for cesarean section. Lazard,[59] who has reported fatalities directly due to tubal sterilization, is convinced that hysterectomy is a safer method of sterilization. Pelvic delivery and sterilization at a later date are much safer procedures. To sterilize a woman simply because she or her husband requests it, and are willing to assume the risk makes a robot of the obstetrician. Since sterilization is not without risk and cannot be undone, it should always be carefully considered. Though it is common practice to offer sterilization at the time of the third cesarean section, we see no good reason for it. Shaw[59] has reported seven cesarean sections on the same patient, and McSweeney[63] recently reported a case of cesarean section for the ninth time.

Myomectomy is accompanied by hemorrhage and the danger of infection and intestinal obstruction. Even breaking up adhesions adds to the risk of operation. When peritoneal bands are encountered during the course of a repeated cesarean, every effort should be made to avoid their extensive separation.

TYPES OF CESAREAN SECTION

It is clear that the obstetrician must, in every case, weigh very carefully the advantages and disadvantages, the dangers and difficulties of the various types of cesarean section which have been devised to minimize the risk of operation in the presence of infection. All types have a place, yet, no matter which operation is selected, the risk largely depends upon the same factors: (1) duration of labor, (2) time of rupture of the membranes, (3) extent of vaginal interference, (4) incidence of actual infection, (5) skill of the operator, and (6) the preparation and facilities for combating complications such as shock and hemorrhage. Even though bacteria may not be present in the uterus at the time of operation, in twenty-four hours or less they are always present in close proximity to an incision which com-

municates with the peritoneal cavity. Infection of the uterus is a fairly consistent finding. Harris and Brown[37] found no sterile cultures at the time of operation when labor had lasted six hours or more.

Reynolds[81] was first to call attention to the dangers of long labor, and Routh[84] later pointed out the significance of interference as well. Holland[43] and later Gordon[31] following their plan of analysis closely, showed conclusively that mortality depends upon the same factors. The following table shows this clearly.

	Cases	Mortality Per Cent
Reynolds (1907)		
Before labor	82	1.2
After a test of labor	158	4.0
Late in labor	49	12.0
Routh (1911)		
Clean cases		
A. Not in labor	245	3.6
B. In labor, membranes intact	224	2.2
Total	469	2.9
Suspicious cases		
C. In labor, membranes ruptured	166	10.8
D. Frequent examinations or attempts at delivery	64	34.3
Total	230	17.3
Holland (1921)		
Contracted pelvis		
A. Not in labor	1202	1.6
B. Early in labor, within six hours	389	1.8
C. Late in labor	220	10.0
D. After attempts at induction	35	14.0
E. After attempts at delivery	107	25.7
Gordon (1928)		
A. Not in labor	343	3.5
B. Early in labor	110	6.4
C. Late in labor	403	7.7
D. After attempts at induction	1	0.0
E. After attempts at delivery	14	13.6

The classical operation is still performed by many who maintain that primary results are no different in either segment, or that no

positive advantages have been shown for the low operation, at least in elective cases. Others select classical section because it is somewhat less difficult and time consuming, or because they believe there is no good reason for the lower segment operation if the patient is to be sterilized. Its advocates contend that the very thickness of the uterine muscle makes approximation easier, protecting the peritoneal cavity from seepage through the wound, and that there is actually but little danger of rupture of the scar when the operation has been properly done in noninfected cases. They argue that there is no more reason for exposure of the bowel than in the low operation, in which extraction is made difficult by an incision naturally shortened by fear of injury to the bladder or the venous reservoir in the broad ligament. Bonney,[7] on the other hand, has said that the chief technical drawback to the classical operation is the fetal trauma associated with the species of version incident to delivery of the breech; and that the fetus usually delivered head first is the principal advantage of the low operation, though forceps' application may not be easy and hemorrhage may be free. It is said, too, that in the classical operation, the placenta is less often disturbed until after extraction of the fetus, and that there is much less danger of hemorrhage when performed for placenta previa. Holmes[45] believes that the actual location of the incision makes no difference at all, the operator being the important factor.

Classical cesarean section with high incision has been relegated to the past. The low classical operation has a limited application and should not be performed at all on women in labor, since the lower segment operation is safer and generally applicable.

Classical Cesarean Section. The abdomen is opened in the midline by an incision extending from about 1 to 2 cm. above the symphysis pubis almost to the umbilicus. Hemostasis should be effective and skin protection careful. Any undue degree of dextroversion or torsion should be noted. The position of the round ligaments will help, and the assistant should correct abnormal positions by either pressure on the right side of the abdomen in the case of dextroversion or by grasping the fundus of the uterus and turning it in the case of dextrotorsion. Failure to recognize these abnormal positions may result in a misplaced incision and undue hemorrhage. The abdominal wound should be surrounded by laparotomy pads and the retractors placed. The bladder reflection at the lower angle of the wound should be visible.

Traction sutures of chromic catgut may be placed at the upper and lower ends of the region to be incised. An ampoule of pituitrin can be given at this time as prophylaxis against hemorrhage. The length of the uterine incision should be sufficient to permit easy extraction of the baby, which should never be dragged through a small incision. Ordinarily about 10 to 15 cm. will suffice. The incision should lie in the contractile portion of the uterus with its lower end a little above the bladder reflection, and occasionally including part of the lower uterine segment. The incision, best begun with a scalpel by cutting the uterine muscle down to, but not into the bag of waters, may then be extended superiorly and inferiorly with a bandage scissors. The use of two fingers in extending the incision may preserve the membranes which are now ruptured. While the amniotic fluid is aspirated, the hand of the operator is introduced into the fundal region of the uterus and one or both feet of the baby are grasped. In extracting the baby, care should be taken to follow the usual technic for breech extraction with especial care of the aftercoming head. Intracranial hemorrhage may occur from the trauma of suprapubic breech extraction just as in pelvic delivery.

Occasionally, the placenta may be encountered under the uterine incision and although this may be suspected when the round ligaments converge toward the pubis or there is a violaceous appearance of the uterine wall, often there is no evidence of its presence. In any case the same technic should be employed with as much speed as is consistent with safety since the hemorrhage is likely to be profuse. If the placenta is reached by the extended uterine incision, the hand may be insinuated between it and the uterus to grasp the feet of the baby, but usually the operator must cut speedily and boldly through it.

When the child has been extracted, the umbilical cord is cut between clamps and the baby handed to the assistant, who waits beside the surgeon with his extended arms covered by several layers of a folded sterile sheet. If local anesthesia has been used, the patient may be given morphine gr. ¼ at this time, or shortly before.

While awaiting separation of the placenta, interrupted No. 2 chromic catgut sutures are placed in the myometrium starting at both angles of the uterine wound. These sutures should reach to but not penetrate the decidua, and are to be left untied until the placenta has been extracted. Traction on the sutures will aid in hemostasis and in placing others. When the placenta has separated, it may be

extracted by gentle steady traction on the cord. If hemorrhage is profuse or separation tardy, the placenta should be extracted without awaiting separation. The sutures already placed are now tied and others inserted to complete the first row. This row should include about the lower two-thirds of the uterine muscle. A second more superficial row of interrupted chromic catgut sutures is now placed with the sutures spaced between those of the low row. These two rows of sutures are generally sufficient for approximating the cut myometrium without gaping. The sutures should be about 1 cm. apart, and although tied sufficiently firmly for hemostasis and accurate coaptation of the edges, they should not be tied too tightly else necrosis with separation of the wound or a weak scar will result. The uterine peritoneum is now closed with a continuous inverting locked stitch, using plain catgut. After gently sponging the pelvic cavity of blood and fluid, it is desirable to bring the omentum down to cover the uterine incision in the hope of preventing later intestinal adhesions.

The abdomen is closed in layers. We prefer to use silk, but whatever the type of suture material, careful attention should be directed to closing the peritoneum; and here the posterior layer of the rectus fascia should be included in the suture, since serious separations of wounds usually begin in a small opening in the peritoneum.

Lower Segment Cesarean Section. Advocates of the lower segment operation contend that immediate results are better, and troublesome postoperative complications rarely follow because peritoneal soiling is confined to the pelvis. They are sure that there is less bleeding since that area is less vascular, and that the incision can be completely and readily covered with peritoneum. If adhesions occur, they involve only the bladder, not the mesentery or intestines, and hence do not give rise to intestinal obstruction. Remote results are better in that menorrhagia and sterility occur much less frequently than after classical cesarean section; and rupture of the scar is much less common and not so likely to be fatal so that future vaginal delivery may be allowed with greater safety.

Marshall's[64] statistics are remarkable. He has reported 246 lower segment operations without a maternal death; in seventy cases in which infection was present or suspected, labor had been surgically induced in fifteen, forceps delivery had been attempted in five and in ten more a variety of other manipulations had been carried out.

[33]

It is clear that the relative merits of the upper and lower segment operations must depend upon the accumulation of a large number of statistics in which all the factors of success or failure are carefully weighed. This is not easy, however, for it is not uncommon for hopelessly infected patients to survive either type of operation, or for women not in labor to die of severe infection. In many series classical section carries the burden of risk incident to constitutional disease. On the other hand, the lower segment is reserved by many for infected cases, or at least for those in labor with membranes ruptured, and so may be accompanied by a higher mortality due to preoperative infection or the indication rather than to the operation. As DeLee[15] has pointed out, it would seem clear that if the low operation is selected because of its greater safety in infected or doubtful cases, it should for the same reason be safer in clean cases. No cesarean section is safe if a virulent organism is present or introduced at the time of operation.

Matthews and Acken[65] reviewing 1,066 cesarean sections, show a mortality of 3.9 per cent for classical and 1.9 per cent for the low flap operation. In a careful analysis of this large number of gross figures, they found that the high classical operation "failed in the prevention of sepsis," while there was no fatality from sepsis in the low operation group. There was no mortality in the secondary low flap operation, while the secondary classical sections showed the same rate as the primary; all of the deaths in the repeated cesarean groups followed the high classical operation, five of their eleven deaths being due to intestinal obstruction. After rupture of the membranes the classical mortality rate far exceeded that from the low flap technic, and "the results of the repeat cesarean section furnished considerable evidence for the superiority of the low flap technique." In fact the deaths in lower segment cesarean section were attributed more to the operator than to the operation itself.

This evidence from a fairly large group of obstetricians in a hospital devoted entirely to obstetrics is important. The lower segment operation has grown so steadily in popularity, that many have come to have undue confidence in it, forgetting that the risk in any type of cesarean operation depends upon the same factors. Safety decreases markedly after labor of ten hours with membranes ruptured for six hours.

Operative Field. Reynolds[82] has shown that the isthmus uteri does not participate in the general uterine hypertrophy of pregnancy,

since its elastic and fibrous tissue do not undergo hypertrophy. Stretching and dilatation occur. Frankl[27] has shown that it is this area which stretches in late pregnancy and labor to form the lower uterine segment. With the upper limit at the lower level of firm peritoneal attachment to the corpus, and its lower the supravaginal cervix at the level of the internal os, the lower segment stretches and lengthens as labor progresses, until the entire cervix is taken up with full dilatation. Its peritoneal covering and the venous reservoirs laterally stretch with it, so that late in labor the vesico-uterine fold is difficult to pick up with forceps, and the uterine veins are found stretched, less tortuous and distended.

At term, before labor has begun, the operative area is in the pelvis, its depth depending upon the extent of engagement of the vertex; while, if the head is high or overriding, it is found partly or wholly in the abdomen and readily accessible. The lower uterine segment at term in any case is of sufficient dimensions to allow a crescentic transverse incision to lie wholly within it. There is more difficulty in placing the vertical incision entirely within the lower segment though this is aided by increase in the length of the lower segment as labor continues, or by overriding, the very conditions one is likely to meet in cases of cephalopelvic disproportion after a trial of labor.

Uterine Incision.   Incision in the lower segment may be vertical or a modification of the transverse type. It is highly desirable that its entire length be in the stretched noncontractile lower segment, and not extend into the corpus. Marshall[64] states that the transverse incision will fall in the lower segment when the patient is not in labor and until the cervix is half dilated, between the cervix and lower segment or actually in the cervix when dilatation is complete or nearly so, and in the cervix itself if the operation is performed late for obstructed labor, or when a high retraction ring is present. The vertical incision he believes, may be kept in the lower segment when the patient is in labor and the cervix at least half dilated; in obstructed labor it will die in the lower segment and cervix, but in a considerable proportion of all other cases the corpus will be included in the incised area. (Figs. 3 and 4.) Our experience coincides with this.

DeLee[17] and Beck,[5] who are prominently identified with the development of the lower segment operation in this country, prefer the vertical incision. Irving has observed rupture of the scar in four

cases in which the transverse operation had been performed else-
where. DeLee insists that proximity of the ends of the transverse
cut to large vessels invites hemorrhage, thrombosis and embolism.
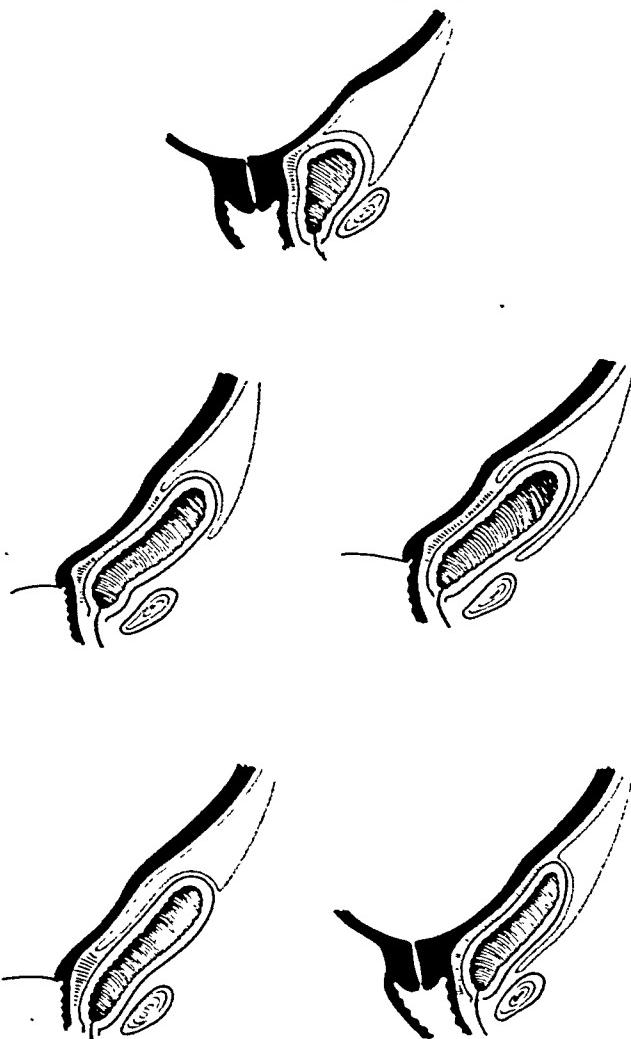
Fig. 3. Relations of bladder, uterus and peritoneum. Up-
per: Common arrangement before onset of labor. Mid-
dle: Arrangements commonly met late in labor. Lower:
Arrangements rarely seen. (From Marshall, C. McI.
Cesarean Section. P. 44. Baltimore, 1939. The Williams
and Wilkins Co.)

He believes, too, that the median scar is stronger, because it is not
under strain during healing, and so less likely to rupture in sub-
sequent pregnancy; if suppuration should occur, it is more readily
controlled.

The transverse incision grows steadily in popularity because it
may be kept wholly within the lower segment or even the cervix,
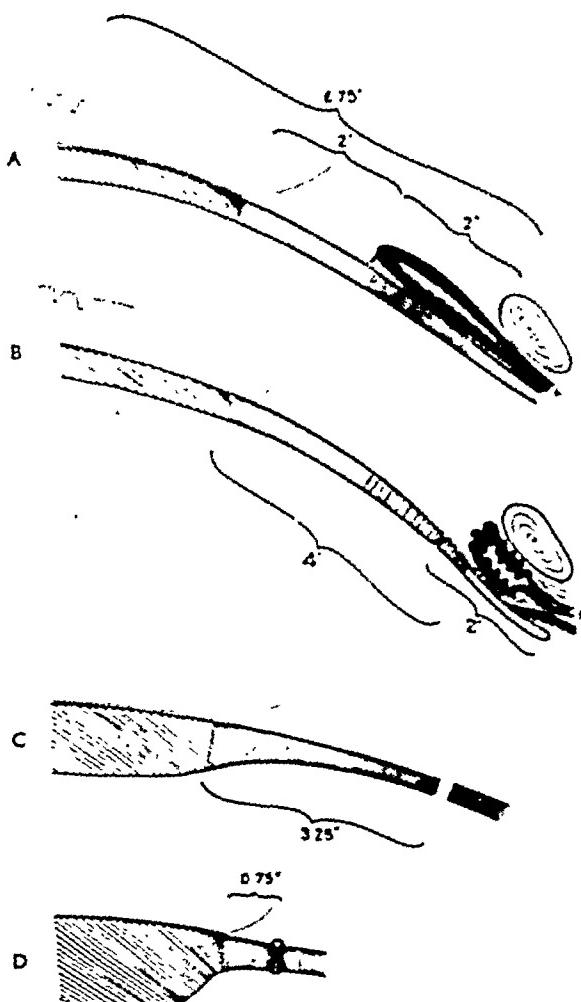
Fig. 4. Measurements from an actual patient operated upon in labor, with the cervix about three-quarters dilated. A, the relationships of the bladder to lower uterine segment and cervix are shown. The junction of the corpus and lower segment was accepted as occurring at the level where the peritoneum obtained firm union with the uterus. The cross-hatched area represents the region between lower segment and cervix. B, bladder mobilized and retracted and the uterus incised. C, after delivery of the child but before the delivery of the placenta. The upper flap of the lower segment *apparently* of considerable length. D, after birth of placenta and corpus strongly contracted. Incision only 0.75 inch below lower border of corpus, therefore, in this case the incision fell in lower segment and *not* in cervix. (From Marshall, C. McI. Cesarean Section. P. 54. Baltimore, 1939. The Williams and Wilkins Co.)

the slight upward curve allowing sufficient room for extraction of the fetus without danger of extension into the venous reservoir. Peritonealization may be carried out with ease and with less dissection of the two peritoneal flaps. The vertical incision is often less satisfactorily covered with peritoneum as the upper flap is more closely attached in the midline and so may be buttonholed, and it may be difficult though necessary to draw the lower flap unduly high on the uterus. Kerr and Hendry[3] proposed the transverse incision, but Phaneuf[4] apparently was the first to stress the importance of placing it well behind the bladder.

According to recent anatomic research it appears that the transverse moderately curved incision is more likely to heal well than the vertical incision. Marshall[5] has well summarized the work of Goerttler[6] who has shown that the essential structure of the wall of the uterus is two intersecting systems of muscle fibers, each the mirror image of the other; the fasiculi of each side arise beneath the peritoneum and run downward and inward to intersect with the opposite side, and end in the endometrium. In the corpus this intersection is at a right angle, in the isthmicocervical segment the angle is obtuse, while in the cervix itself the arrangement is almost circular. Since it appears that the sutured transverse wound should heal under optimum conditions, we prefer the transverse incision.

Technic of the Lower Segment Operation. The abdomen is prepared and opened as in the classical operation. Trendelenburg position is helpful, but inadvisable if infection is suspected. Selecting a point in the vesico-uterine fold, usually about 2 cm. above the bladder reflexion, the peritoneum is picked up with forceps and cut with Mayo scissors. (Fig. 5.) After mobilizing the peritoneum laterally in each direction by a procedure in which the opened scissors is introduced repeatedly and then opened, the uterine peritoneum is cut in a crescentic fashion with the concavity upward. Underlying tissue, generally highly vascular, should be avoided. An upper peritoneal flap is raised by blunt scissors dissection. The lower flap must be fully separated well down into the pelvis so as to place the uterine incision as low as possible in the lower segment or cervix. (Fig. 6.) Occasionally, a well defined band of connective tissue attaching the bladder medially to the uterus must be cut. These flaps should be retracted as widely as possible, and a well rounded retractor used to hold the lower flap and bladder against the symphysis pubis.
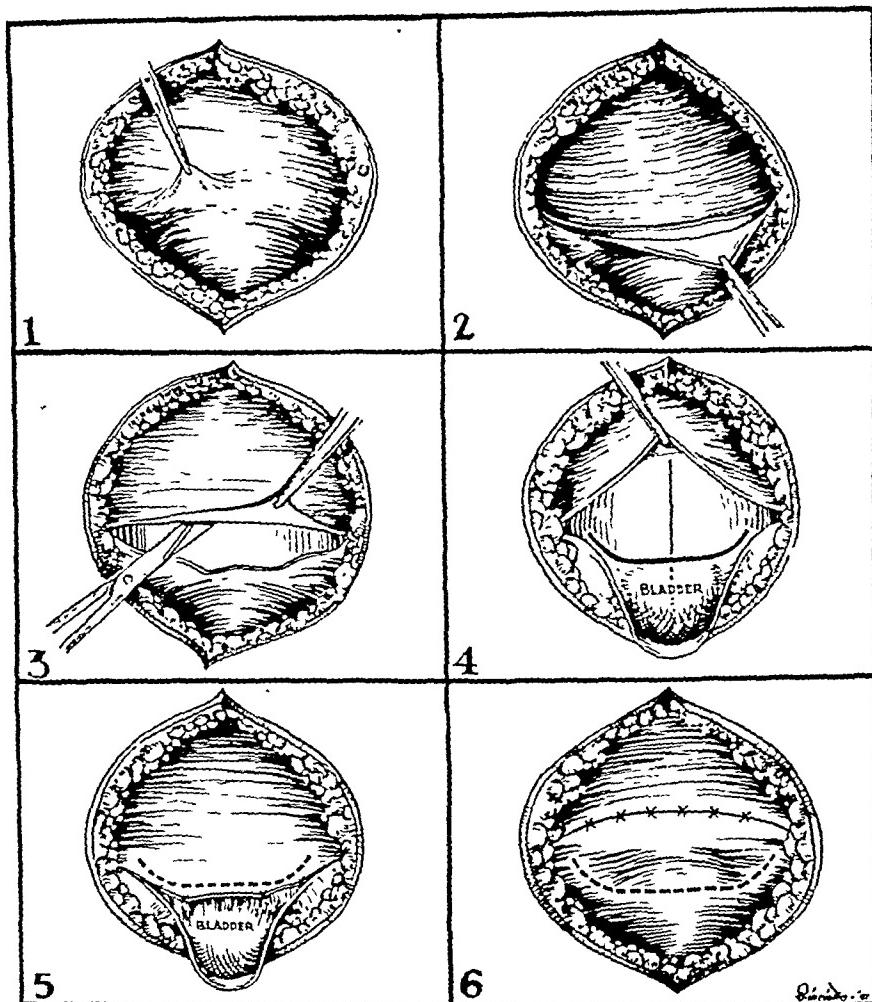
Fig. 5. The lower segment operation. 1, the bladder is seen inferiorly. The forceps picks up the loose peritoneum covering the lower uterine segment at about 2 cm. above the bladder reflection. 2, the peritoneum covering the lower segment of the uterus has been cut transversely by a curved incision, with the concavity directed superiorly. The forceps lifts the edge of the lower flap, which, with the bladder, is dissected from the uterus. 3, the upper flap of peritoneum is dissected from the uterus with the Mayo scissors. 4, the two flaps are retracted to show the lower uterine segment and the position of the uterine incision. The heavy curved transverse line represents the position of the transverse incision recommended. The lighter vertical line represents the position and extent of the vertical incision preferred by some operators. 5, the fetus has been extracted and the uterine incision closed. The upper peritoneal flap has been sutured to the uterus by four interrupted catgut sutures as indicated. The position of the uterine incision is shown by the curved dotted line. 6, the lower bladder peritoneal flap has been brought over the lower segment and sutured superiorly. Note the bladder covering the uterine incision.

A small incision in the uterus is lengthened laterally with bandage scissors, and the fetus extracted. Pituitrin or ergonovine is best given when this has been done. The placenta is delivered by pressure on
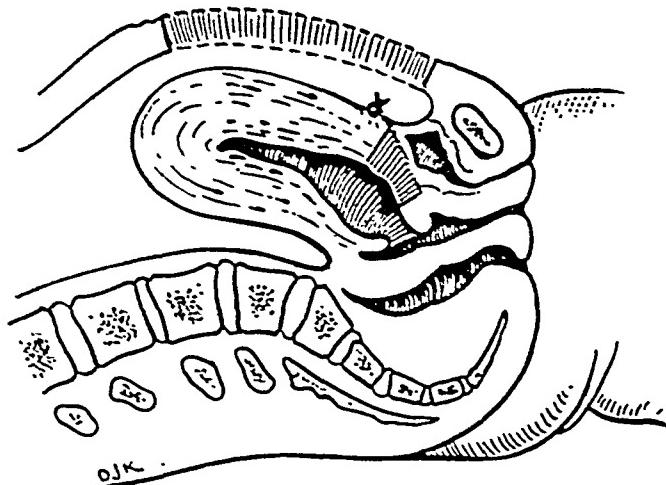
Fig. 6. The suture shows final position of uterine wound after closure and restitution of uterovesical peritoneum and bladder, when care has not been taken to make the transverse uterine incision sufficiently low. (From Marshall, C. Mcl. Cesarean Section. P. 102. Baltimore, 1937. The Williams and Wilkins Co.)

the fundus through the abdominal wall and steady traction on the cord. Great care should be exercised to see that the membranes are completely removed.

The uterine wound is then closed in two layers, using No. 1 chromicised catgut interrupted sutures about 1 cm. apart for the myometrium, and the same material as a running suture for coaptation of the segmental fascia. The end sutures should be left long to be used as tractors, as the uterine wound tends to sink into the pelvis with closure. The upper edge is often much thicker than the lower, yet careful approximation is not difficult if sutures are placed properly. The lower the incision, the less this becomes necessary. No harm comes of inclusion of decidua in the first layer of sutures. Hot laparotomy pad pressure assists final hemostasis. The upper peritoneal flap is then fastened below the incision by a few fine plain gut sutures, and the bladder flap drawn up and sewed down in a similar fashion. The incision is now covered by two layers of peritoneum, or if low enough, by a layer of peritoneum and the base of the bladder. The operation which has been simplified by raising the

lower flap alone does not provide the protection of double peritonealization. The abdomen is then closed. Some advise drainage.

Extraction of the fetus and placenta often present special problems. When the occiput is posterior it may be rotated anteriorly by placing a finger in the baby's mouth, and then extracting with forceps, or by using one blade as a vectis. Forceps should be ready, for even in anterior positions simpler methods may fail. Rarely fixation of the presenting part in the pelvis may make it necessary for an assistant to dislodge the head by inserting a finger in the rectum, or even by vaginal manipulation. We have never had to do this, however. When a large part of the fetal head lies below the level of the incision it is better to lift it by pressure applied through the uterine wall than by the hand in the uterus.

Manual removal of the placenta should not be practised unless hemorrhage arises from partial separation, or separation is too long delayed. Kerr[52] removes the placenta, in cases advanced in labor, by dropping the cord clamp into the vagina, and having an assistant draw it out, and states that it will almost certainly come away easily if sterile water or salt solution is injected into its vessels. He believes that every device should be used to avoid abdominal removal of the placenta with peritoneal contact of infected tags of membrane from the lower segment or vagina. Disinfection of the uterine wound or the entire lower segment has been suggested.

Peritoneal Exclusion Cesarean Section.   Cesarean section may be performed either in the corpus or lower segment of the uterus after approximation of the parietal to the visceral peritoneum, thus forming a space outside the general peritoneal cavity through which delivery may be effected. The operation is performed by some in cases that need cesarean section when long labor, repeated examinations or attempts at delivery have resulted in potential or actual intrauterine infection. It is intended to protect the general peritoneal cavity against contamination from the spill of infected uterine contents at the time of operation and from leakage subsequently.

The operation resembles in its indication the lower segment operation with extraperitoneal closure and the true extraperitoneal operation. It will protect the infected case against peritonitis better than the former but not as well as the latter operation. The exclusion operation has not gained nor apparently merited the popularity of the lower segment operation. The simplest form of the exclusion operation with the uterine incision low in the corpus, should find its

greatest application in instances in which the operator is unable to do a more technically difficult operation. The technic of the operation follows:

Veit-Fromme-Hirst.[41]   The abdomen is opened through a midline incision beginning just above the pubis and extending to a few centimeters of the umbilicus. The visceral peritoneum covering the lower uterine segment is incised to the bladder and both are separated. The edges of the parietal and visceral layers of peritoneum are united by interrupted sutures of fine catgut. The uterus is then incised longitudinally in the lower segment and the child and placenta delivered. The uterus is closed in the usual fashion. Continuous fine chromic catgut may be used to reinforce the union of the two layers of peritoneum. Drainage is included when indicated. This operation may be better if performed in the lower segment through a transverse incision.

Irving's Modification.   Irving[47] noted that the thin layers of parietal and uterine peritoneum often tore during the extraction of the fetus, so that the operation ceased to be extraperitoneal. He proposed a modification that is the simplest of the exclusion operations. The abdominal incision is the same as for the classical cesarean except that it is somewhat higher, its upper angle extending about an inch above the umbilicus. No walling off pads are used. The conjoined layer of peritoneum and fascia is sewed first at the upper and lower angles of the wound to the anterior surface of the uterus with interrupted mattress sutures of No. 1 chromic catgut. Each stitch penetrates the conjoined layer of fascia and peritoneum, takes a bite in the uterine peritoneum and muscularis, and emerges again through the conjoined layer. Similar stitches are inserted on each side, parallel to the edge of the wound and about a quarter of an inch outside it, until there is a firm union between the uterus and the abdominal wall and an oval area on the anterior surface is excluded from the peritoneal cavity. The uterus is incised vertically in this space, and the fetus, placenta and membranes removed. If there is any considerable bleeding, a gauze pack is inserted, to be removed twelve hours later through the vagina. The uterus is sutured in the classical manner. A cigarette drain to the uterus is placed in the lower angle of the wound, and the conjoined peritoneal and fascial layers are united in the midline by interrupted catgut sutures.

This operation may result in high fixation of the uterus with resultant sterility, and later operation may become necessary. Since

a transverse incision in the lower segment is preferable, E. F. Smith[91] proposes such a technic through a Pfannenstiel incision. Fixation of the lower segment to the abdominal wall will not follow this operation, which is recommended for women with potential infection.

Extraperitoneal Cesarean Section. Structural changes in the lower abdomen and pelvis during pregnancy and especially labor make it possible to expose a sufficient area of the lower uterine segment to perform cesarean section extraperitoneally. During pregnancy the bladder rises higher with increase in the length of the lower uterine segment and loosening of the endopelvic fascia. The anterior cul-de-sac is often obliterated. (Fig. 3.)

It may be necessary to perform cesarean section when probable or actual intrauterine infection is present. A true extraperitoneal operation should decrease the risk of postoperative peritonitis and at the same time conserve the uterus. There can be little question of the advantages of a technic that would enable the obstetric surgeon to perform a true extraperitoneal operation when it is indicated. The modern operation developed by Latzko[57] has been recently modified by Waters.[96] The Latzko procedure is based on lateral displacement of the bladder and peritoneal reflextion, and the Waters on direct supravesical approach. Descriptions of the technic follow:

Latzko Operation. The bladder is catheterized and distended by the instillation of 200 cc. of boric acid solution. The catheter is left *in situ*, but clamped and attached in such a way that the bladder may be emptied or refilled when necessary. High Trendelenburg position is employed. A midline abdominal incision extends from the symphysis pubis to the superior limit of the distended bladder. Care should be taken with incision of the fascia that the bladder and peritoneum are not included. Separation of the bladder should begin on the left side since the common dextroversion and dextrotorsion of the uterus make this part of the bladder more readily accessible.

The upper left portion of the bladder is freed and separated from the anterior uterine wall and the left rectus muscle retracted. Further separation of the bladder is done carefully while the bladder is retracted to the right. The loose connective tissue of the endopelvic fascia holding the bladder to the fascia covering the lower uterine segment is separated. Similar dissection of the tissue which attaches the vesico-uterine peritoneal fold to the fascia of the lower uterine segment is made, thus enabling this fold to be displaced superiorly. Emptying of the bladder and retraction to the right will expose a

[43]
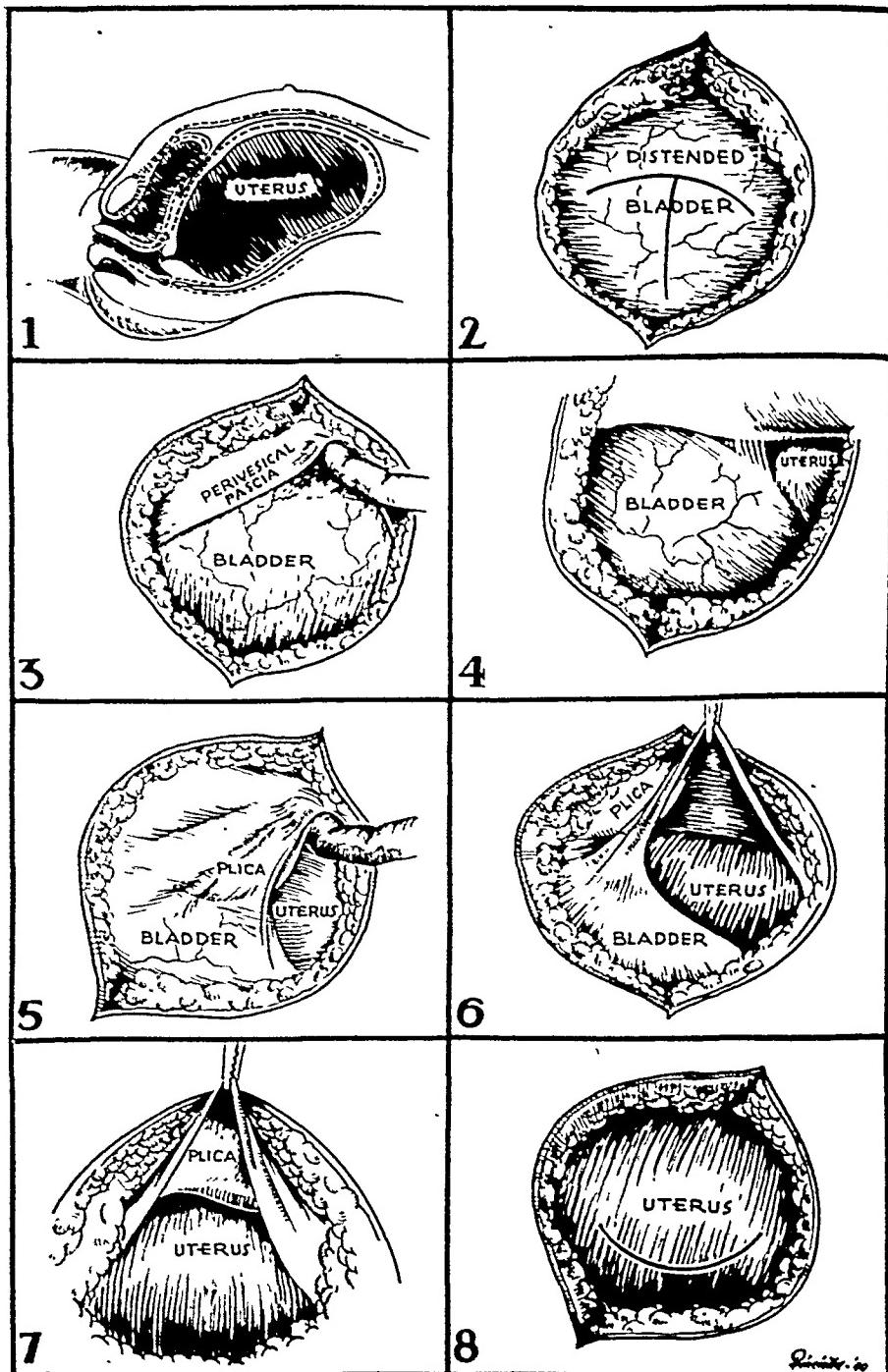
Fig. 7. The extraperitoneal cesarean section (Waters). 1, a sagittal section of the abdomen showing the relationships of the fascia and folds of the peritoneum. 2, the T-shaped incision in the fascia covering the bladder is indicated. 3, the finger is separating the perivesical fascia from the underlying muscle of the bladder. 4, the relationship of the uterus, bladder and lower edge of the plica of peritoneum are represented. The figure shows a few fine filaments of connective tissue between bladder and fascia. 5, 6, and 7, further steps in the separation with final exposure of the lower uterine segment. 8, the position of the lower uterine incision.

broad area of the lower uterine segment sufficient for extraction of the fetus.

When it appears that this fold may be torn either in its dissection or during extraction of the fetus, Aldrich[1] incises it deliberately on the left side, and resutures its edges before the uterine cavity is opened.

The lower uterine segment is opened by an incision that extends from the symphysis pubis to the peritoneal reflextion, and the child is delivered by forceps application and extraction. Pituitrin is given, and after delivery of the placenta the uterine incision is closed by interrupted chromic catgut sutures. A second layer of sutures reinforces the closure. The bladder is again distended so that possible injury may be detected and then emptied. The peritoneal fold is now replaced with a few fine catgut sutures, and the abdomen closed with a pelvic drain in the lower angle of the wound.

Waters Operation. The abdomen is opened by a left paramedian incision extending from the pubis to 2 cm. below the umbilicus. The bladder is distended with 200 cc. or more of sterile solution, preferably colored with a little methylene blue. The transversalis fascia and perivesical fascia are incised down to the bladder muscularis for about 2 to 3 cm. at about two-thirds of the distance to the bladder fundus. The vesical vessels are seen lying upon it. A blunt instrument is inserted between the muscularis and perivesical fascia, the fascia freed, and then incised transversely over the top and left of the bladder in a "T" fashion. (Fig. 7.) It is important to reach the plane between bladder and perivesical fascia. It can be recognized not only by the blood vessels at this level, but also by the bulge or herniation of the bladder that occurs when the fascia has been incised to its full depth.

The parietal peritoneum above the bladder is carried up with the fascia, and the bladder separation is begun. The bladder is now drawn downward, the vesico-uterine plica found and the bladder emptied. The plica may be seen on the left side of the bladder superiorly. The areolar tissue in this area is easily separated by holding the bladder down and separating by blunt dissection. When the plica is seen the finger may be insinuated beneath it, and dissection from this point more readily carried out. When the finger is in position the following relationships may be noted. Below the finger is the perivesical fascia at the back of the bladder, behind is the peri-uterine segmental fascia and the uterus, and on the finger is the plica

which represents the lowest level of the peritoneal fold of the utero-vesical pouch or anterior cul-de-sac. It resembles a hernial sac and its integrity must be maintained if the operation is to be truly extra-peritoneal. The vesico-uterine plica with its underlying fascia must be freed.from the posterior surface of the bladder so that the bladder can be completely retracted. The perivesical fascia must again be cut to accomplish this but this time at the junction of uterus and bladder. In separating the plica great care must be exercised to include the underlying fascia as well, else perforation of the peritoneum is likely to occur. The success of the Waters operation depends upon treating the peritoneum and its underlying fascia as a single structure that can be separated easily. Attempts to free the peritoneum alone will almost always result in tearing. When the bladder has been well retracted the lower uterine segment is exposed and may be incised in the transverse crescentic manner described under the lower segment operation. Delivery of the child and closure of the uterine incision are carried out as described previously. The bladder should be refilled to discover the results of any undue trauma and the retrovesical space drained with rubber tissue.

Cesarean Hysterectomy. Cesarean section followed by supra-vaginal or total hysterectomy is sometimes called radical cesarean or Porro operation. When Porro[77] removed the uterus, however, he effected hemostasis with Cintrat's serre-noued, a wire snare which tightly encircled the uterus at the level of the internal os. The wire loop was tightly drawn, tightened again on the third postoperative day and removed on the fifth. Since it has been so often stated that Porro used an elastic ligature for this purpose, an actual photograph of the instrument he used in his classic procedure is reproduced. (Fig. 8.) The modern cesarean hysterectomy is not a Porro operation.

Cesarean hysterectomy finds its greatest application in cases of severe uterine infection, when suprapubic delivery is necessary. Extraperitoneal cesarean section will not afford the same measure of protection. Hysterectomy after cesarean section may also be indicated for uterine myomas, separation of the placenta, placenta accreta, rupture of the uterus, cancer of the cervix and uncontrollable postpartum hemorrhage.

Technic. The abdomen is opened in the midline from the pubis almost to the umbilicus. If infection is present, laparotomy pads should be carefully placed so as to reduce peritoneal soiling to a minimum. The uterus is then incised, as in the classical operation,

fetus and placenta extracted, and the uterine incision rapidly closed by three or four deep hemostatic sutures. The broad ligaments are then divided between clamps close to the uterus taking care to
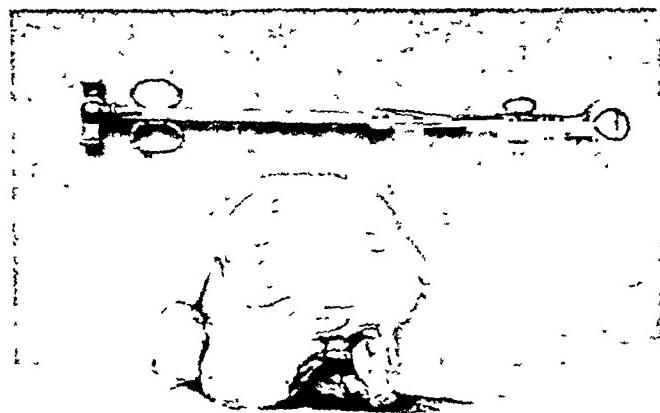
Fig. 8. Wire snare used by Edordo Porro in his first cesarean hysterectomy, May 21, 1876. The left tube and ovary were included in the loop. Note the oblique incision in the uterus.

include the tubes and round and ovarian ligaments. An anterior peritoneal flap is raised by incising the vesico-uterine fold. The uterine vessels are secured by Ochsner clamps pointing inward and downward to the cervix at about the level of the internal os. The cervix is now cut through transversely. Ligation of ovarian vessels should be carried out without opening the broad ligament which may bleed freely. Ligation of uterine vessels is made safe by traction on the cervix and suturing them to it. The cervix is now covered, without .entering the canal, by approximating its fascial covering with chromic sutures. There will be no difficulty finding ample peritoneum to cover it smoothly. The broad ligament is now closed, tacking the round ligaments to the cervix. The abdomen is closed without drainage.

Various modifications of this technic may be found desirable. The unopened uterus may be eventrated, the abdominal wall partially closed behind it, the peritoneal cavity protected by large pads and hysterectomy performed. If the fetus is alive, this must be accomplished quickly or it will perish. Hysterectomy may be total, or subtotal, particularly in the case of rupture of the uterus involving the cervix, and in this event, the vaginal vault should be carefully

[47]

closed, using interrupted chromic sutures. If removal of the uterus should become necessary for hemorrhage in the course of the transverse lower segment operation, hysterectomy is best performed by continuing the incision circularly around the lower segment.

Cesarean Section with Exteriorization of the Uterus. The treatment of frankly infected cases has long been a serious problem. In 1908, Selheim[88] sutured the open uterus to the abdominal incision, thus forming a utero-abdominal fistula for drainage until the uterus was later freed and replaced in the pelvis. In 1924, Portes[79] first performed exteriorization of the uterus, though this procedure had previously been proposed by Gottschalk.[35] The intent was to remove the uterus and adnexa from the abdominal cavity until the danger of peritonitis had passed.

Portes Operation. The operation is rarely performed, but may have a definite place in operative obstetrics. It is indicated in the grossly infected case in which abdominal delivery must be done after repeated attempts at vaginal delivery have failed. It resembles cesarean section followed by hysterectomy in its indication, but has the advantage in that it is less time consuming and traumatic to the patient, and is the better procedure when the patient is a poor surgical risk because of shock. It has also the advantage of conservation of the uterus, and cases in which subsequent pregnancies have been carried to term have been recorded.[73] In the event infection of the uterus is so extensive that sepsis seems uncontrollable, hysterectomy may be performed extra-abdominally when the patient has recovered from shock.

Technic. The operation is performed in two stages:

First stage: The abdomen is opened by a long incision beginning a little above the pubis and extending well up into the upper abdomen. The uterus is delivered and covered by moist laparotomy pads or towels. The abdominal wall is closed behind the uterus down to the cervix. Before the uterine corpus is incised, the area about the cervix should be carefully filled with dry laparotomy pads to prevent spill of the usually grossly infected uterine contents into the general peritoneal cavity. After extraction of the fetus and placenta the uterus is sutured in two layers as in the classical section, and then covered by moist dressings. The uterine incision may burst open, or it may become necessary to remove the sutures.

Second stage: After about five or six weeks, when involution is largely completed and the uterus clean and its scar well healed, the

abdominal incision is partially reopened, the uterus freed from its adhesions and dropped back into the pelvis. Drainage is indicated.

POSTOPERATIVE CARE

Application of the dressing after completion of the operation should receive careful attention. Whatever the method, the wound must be protected against the possible strain of coughing or vomiting. The adhesive straps should reach sufficiently posteriorly so that moderate traction can be used in placing them. The superior strap should be gently applied as to allow for postoperative distention, and should not reach above the level of the umbilicus, so that a relaxed fundus may be massaged if necessary. A good plan is to place the first straps obliquely, the lower ends extending below the iliac crests to the posterolateral regions of the upper thighs and the upper ends to the lower ribs posteriorly on the opposite sides. The transverse straps may then be placed. Before any adhesive tape is applied it is advisable to cover the dressings with waxed paper so as to allow for simple mesial cutting of the tape and ready exposure of the wound when it is necessary to remove the skin clips or sutures on the seventh day. If perforations are placed in the edges of the cut adhesive tape dressing it may then be laced together, thus making it unnecessary to remove the dressing only to apply another, a procedure which often irritates the skin and causes distress.

For the first eight hours after the patient has been returned to bed she should lie flat and then be placed in moderate Fowler position. If there is any tendency to bleeding, ergonovine should be given every four hours for the first day. This medication is used routinely by some. Pain should be relieved by morphine, one-sixth to one-quarter of a grain every four hours for the first day, and by codeine in one grain doses later. Phenobarbital will be just as useful in some cases.

It is generally necessary, even when local anesthesia has been used, to administer fluids parenterally during the first day. Two thousand cc. of normal saline may be given subcutaneously and one thousand cc. of a dextrose solution intravenously. The total volume of fluids for the first day need not exceed three thousand cc. Liquid nourishment may be given on the second day, a soft diet on the third and then a gradual increase to a general diet. The bowels should be opened on the fourth day by an enema followed by daily use of mineral oil, or a gentle laxative or enema when necessary.

The care of the bladder is important, since minor bladder disturbances are common. As noted under preoperative care, if the bladder is empty during the operative procedure it is less likely to be traumatized and exhibit postoperative atony. In any case there is no need for an indwelling catheter postoperatively. If the patient is unable to void spontaneously, she should be catheterized under strict aseptic precautions every six or eight hours to avoid an over-distended bladder. When she has begun to void, the residual urine should be estimated, and when less than one ounce catheterizations may be stopped.

The patient may be allowed out of bed on the eleventh or twelfth day, and to go home on the thirteenth or fourteenth postoperative day. Before discharge, the adhesive tape dressing may be entirely removed and the wound inspected. Following removal of the skin clips or sutures on the seventh day, small transverse adhesive straps may be placed directly across the middle three-fourths of the wound to prevent separation of the skin edges with the later production of a thick scar. A light dressing may be applied or none at all if the wound is clean and the patient has a good abdominal support of some sort.

Cardiac patients should be kept in bed at least two weeks, and examined by a cardiologist before they are allowed out of bed. Then, if warranted, they may remain up for short periods each day, taking on their usual duties slowly for a few months. Nursing, except in mild cases, should not be permitted.

The necessary instructions for the care of the patient at home should be given at this time. The care of the breasts is the same as for any puerperal patient. Finally, adequate postpartum examinations should be made at later dates to determine the ultimate healing of the wound and the involution of the pelvic organs.

COMPLICATIONS AND SEQUELAE

Hemorrhage during the course of the operation should be managed by kneading or massaging the uterus, pushing or pulling it higher into the abdominal cavity and making certain that no placental fragment or piece of membrane has been left adherent to its wall. Pituitrin may be injected into the uterus, or intramuscularly into the deltoid, but not into a vein. Pastore and Stander[72] have reported a high incidence of protein reaction, with one death, following intravenous use of pituitrin. Ergonovine is safe and more

reliable. The uterine cavity may be packed temporarily until the uterus contracts firmly. In placenta previa it may exceptionally be advisable to ligate a vessel in the placental bed, or a twelve-hour uterine pack may be occasionally necessary.

Postoperative shock is largely due to hemorrhage, but minimal bleeding may precipitate it if the patient has been long in labor, or if the anesthetic has been poorly selected or unduly prolonged. Blood plasma or serum should be administered. Intravenous dextrose is valuable only when shock is minimal; later on it is harmful. The indication is to restore blood volume. Cardiac stimulants and adrenalin are contraindicated and harmful. Morphine should be given. Oxygen is indicated while carbogen is not. Body warmth should be conserved, but care should be taken that blood volume is not further depleted by dehydration due to sweating. Transfusion may be indicated later.

Infection of the uterine wound is a serious complication and more commonly follows an operation performed in the presence of actual or potential uterine infection. When it occurs, the location of the uterine incision largely determines the development of peritonitis. The classical cesarean section offers little protection, the lower segment operation affords fair protection and the true extraperitoneal operation in most instances provides the best assurance of safety. The safety of the lower segment operation that includes a transverse incision low in the cervix should equal that of the true extraperitoneal operation, if it is agreed that an infected incision and not anmiotic spill is the important cause for peritonitis.

Local uterine inflammation is not uncommon, and involution is often delayed. Occasionally, it is possible to recognize the formation of a uterine or extrauterine abscess clinically, though the common symptoms of fever, rapid pulse and a tender uterus do not necessarily indicate this complication. Abdominal drainage over Poupart's ligament has been successfully performed in such cases.

Peritonitis is the common fatal complication. It may result from drainage of an infected uterine wound into the abdomen, or lymphatic spread, vascular extension, direct continuity and tubal extension from infected decidua. Lochiastasis will predispose to extension of intrauterine infection by any route and should be watched for and prevented. Vaginal swab cultures or routine intrauterine cultures taken at the time of operation will be the basis for

proper selection of sulfonamide therapy.[33,34,83] No other therapy is specific.

Simple wound infection may occur or actual wound disruption, which may be associated with intestinal obstruction. High temperature and saturation of the abdominal dressings with serous fluid are early clinical signs. Even though skin union is apparently good, on inspection and palpation of the wound the diagnosis is not difficult. Careful reduction of protruding omentum or gut, with their retention by a strip of vaselined gauze and firm adhesive strapping will give better results than resuture.

Pulmonary collapse may occur postoperatively with subsequent atelectasis. Phlebitis, pulmonary embolism and infarct are usually closely related complications of the late puerperium and are always due to sepsis. Morphine is valuable. Though transfusion may appear to be indicated—and it often is—due caution must be exercised for it is not without danger.

The bladder or ureter may be injured during operation. When urinary tract infections complicate the puerperium, it is important to remember that clinical cure is not certain until urine cultures become negative.

Incisional and umbilical hernia and rupture of the uterine scar in subsequent pregnancy are late sequelae. Montgomery[68] believes that hernia is a more common sequel of cesarean section than of any other form of lower abdominal operation. Avoidance of postanesthetic vomiting, careful suture of the abdominal wall and properly applied adhesive dressings are important factors in prevention.

Peritoneal adhesions are a common result of the classical operation, and symptoms of chronic intestinal obstruction may recur from time to time.

It is not possible at present to determine the part played by cesarean section in later sterility or abortion.

PROGNOSIS

It is impossible to discuss the actual mortality of cesarean section in the United States in any but general terms. It is probably at least 10 per cent and possibly approaches 15 per cent. Reports from well conducted clinics and individual operators as a rule show better results than those of local comprehensive surveys. On the whole the risk of operation has been lessened, yet Holland[43] as early as 1921

reported a mortality of but 4 per cent in 4,197 operations in thirty-seven British hospitals.

King[56] in a comparison of two cesarean section surveys in New Orleans found a maternal mortality of 16 per cent in 300 operations performed from 1921 to 1926 and 5.9 per cent in 1,108 operations from 1927 to 1936. Quigley,[80] in 1939, has reported a mortality of 2.9 per cent in 937 cesarean sections for a ten-year period in Rochester and Monroe County, New York. DeNormandie,[19] reporting a total of 2,106 abdominal deliveries in Massachusetts in 1937 found the mortality rate but 3.1 per cent. Irving[46] found a gross death rate of 5.8 per cent in all types of cesarean section in 11,491 cases compiled from seventeen American authors. Arnold[3] comparing all available reports published since Plass'[75] compilation in 1931, quotes thirty American authors reporting 15,768 cesarean sections with a maternal mortality of 4.69 per cent.

Lynch,[62] in 1937, collected a large series of 12,055 cesarean operations with a mortality of 4.1 per cent. Bland[6] discussing this paper said: " In an exhaustive analysis of the world's literature for the past two decades, I found a series of 65 papers devoted to a general survey of postoperative cesarean section mortality. In this series there were recorded 1,843,356 deliveries. Of this number 19,480 (1.5 per cent) were effected by the abdominal route and 1269 (6.5 per cent) of the patients died. In some of the papers published in this country the maternal death rate was unbelievably high. For example in the series reported by Bickel of Indiana it was 17.3 per cent. In the survey conducted in the City of New Orleans it was 16.1 per cent. Magnus Tate in his study reported a rate of 16 per cent. In a survey made in the State of Texas, it was 14.4 per cent. In Europe it runs a deadly parallel and ranges between 6 and 7 per cent. Loss of life is by no means negligible. In the series of 1,843,356 deliveries with 19,480 sections recorded in this country and abroad there were 913 dead babies or a fetal mortality of 4.4 per cent."

In Arnold's tabulation of national cesarean statistics from twenty-five American authors for 1931 to 1939, the fetal mortality was 8.8 per cent in 9,884 cases, ranging from 2 per cent in a series of 347 cases to 17 per cent in 329 cases. Daily,[14] however, has reported 1,000 consecutive cesarean sections performed by fifty operators with but eight deaths, or 0.8 per cent.

If it is admitted that growing emphasis upon the value of the baby is partly responsible for the increasing incidence of cesarean

section, a fetal mortality at least twice as high as the general fetal rate deserves consideration. Fetal and neonatal death are due chiefly to atelectasis, prematurity and intracranial hemorrhage. The indications for cesarean section and complications of pregnancy would appear to be important factors.

Miller[67] in an excellent study of the effect of methods of delivery particularly cesarean section on fetal and neonatal mortality, points out that cesarean section surveys have paid scant attention to the infant, reporting only on its mortality. He believes that the post-cesarean section mortality in premature infants depends almost entirely on the birth weight irrespective of complications of pregnancy. The high incidence of prematurity associated with placenta previa, separation of the placenta and toxemias of pregnancy seriously affects the figures. It is equally obvious that cesarean section simply as a method of delivery should not be associated with higher fetal mortality than spontaneous delivery or low forceps. The opposite should be the case. For practical purposes, fetal mortality will depend upon the birth weight, in the case of cesarean section performed before term, and upon the character and duration of labor at full term.

CONCLUSION

Cesarean section is probably the most valuable therapeutic procedure in the armamentarium of the obstetrician. Its proper use, however, represents a real problem. The continuing increase in its incidence is largely due to a broadening of the indications for operation. The importance of contraindications to operation, however, is not generally appreciated. The increase in the incidence is due in part to the dictum "once a cesarean always a cesarean." There is steadily accumulating evidence that this dictum should be modified, since with more common use of the lower segment operation the risk of rupture of the uterine scar is considerably lessened. In any case, the type of previous section, evidence of previous postoperative morbidity and the occurrence of previous infravaginal delivery are important factors that should be given consideration.

The contraindications to the operation should be well known. While the risk is but one-half of one per cent under ideal elective conditions it rapidly rises with potential or actual uterine infection. Every effort should be made to perform cesarean section early in labor or before labor has begun. A proper trial or test of labor in

borderline cephalopelvic disproportion, and more general knowledge of the value of x-ray study should do much toward lowering the incidence and risk of operation, yet roentgenographic prediction alone, however expert, will not satisfy the obstetrician. His experience is the greatest single factor in the evaluation of indications. Not every abdominal surgeon is qualified to do a cesarean section and those who are ignorant of the risk or unable to weigh its indications or contraindications should not perform the operation regardless of their technical skill.

Selection of the type of cesarean section to be performed should be made with the greatest care. The advantages of the lower segment operation are now so well accepted that the classical operation is rapidly losing favor and today has but limited application. The most recent and important contribution to the technic of the lower segment operation is concerned with placing a transverse incision low in the uterus, behind the bladder and in the cervix if possible. Such an incision in a potentially infected uterus should afford great safety in that an infected wound can find easy vaginal drainage. This operation may be equal to the true extraperitoneal operation in its safety, for there is reason to believe that the amniotic spill is not nearly so important as the remaining infected uterus as a cause of fatal sepsis. For this reason, when the uterus is actually infected and cesarean section is indicated, any operation which leaves the uterus behind is dangerous, and hysterectomy following the section is the procedure of choice.

Cesarean section occupies a prominent place in preventable maternal mortality. Much can be done to reduce the danger of operation. Incidental surgery during the course of the operation is contraindicated. The choice of anesthesia is of great importance. There is considerable evidence to show that spinal anesthesia is especially dangerous for the obstetric patient, and that local anesthesia is safest. Any operator capable of performing cesarean section should be able to give adequate local anesthesia in the usual case. Hemorrhage and shock are common causes for death that can be largely controlled. In every case of cesarean section provision should be made for adequate replacement of blood loss. Blood plasma should always be immediately available in the event that compatible whole blood cannot be quickly secured.

Worldwide statistics clearly show that the morbidity and mortality of cesarean section are higher than for any other pelvic

operation. It is clear that proper appreciation of all the factors concerned with the solution of this important problem will lessen the risk of operation.

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Editorials

MEDICAL STUDENTS, DEANS AND DEFERMENT

A FEW months ago there was a great ado concerning medical students and the draft. We wrote editorials on the subject; other scientific publications also carried editorials. The Deans of our Medical Colleges were in somewhat of a dither, fearing a large percentage of the medical students now enrolled would end up in the army. Spokesmen of representative bodies hurried to Washington to meet in conference and "take up" this matter with the right persons. Then, out of a clear sky a solution was found.

Medical students would receive deferment. An opportunity was provided for junior and senior medical students to enroll in the War Department Reserve Pool. This made it possible for them to continue their studies, serve a year's internship, and then be available for military service as medical officers. All hands believed that these upper classmen, en masse, would stampede for enrollment. However, the truth is discouraging. To date a very small percentage of these young men have bothered to do their duty. If these students persist in avoiding military service, the Army will lack the medical personnel it will require in the future. Under the Selective Service Act deferment could be ended without discussion or previous notice; and if junior and senior medical students persist in the folly of failing to take advantage of this method whereby they can complete their medical studies, this deferment is sure to come to an abrupt halt.

It has been suggested that the Deans of our Medical Colleges can play an important and active rôle in this situation. They can call the upper classmen together and explain the situation in detail, using words of one syllable; or call each student before them individually and explain the why's and wherefore's and then "turn on the heat."

It is believed that the "authorities" have leaned over backward and have been patient and fair. Now the shoe is on the other foot; and no one will complain if, after a reasonable time, medical students are no longer deferred but are inducted into the Army, unless they apply for commissions as second lieutenants in the Medical Administrative Corps or as ensigns in the Navy.

TWO UNUSUAL BIOGRAPHIES: PARK AND WELCH*

DURING the past few years the book readers of this country have been deluged with books written by physicians. Many of them have been autobiographies. At first some of them reached the best-seller lists. Then the public became tired of reading about medical students, hospital life, gory details of human suffering, and turned to fiction and mystery stories.

In 1925, Harvey Cushing wrote the Life of Sir William Osler. It was awarded the Pulitzer Prize for that year. It is still a model of its class. One would think more physicians would write about the giants in our profession rather than being whimsical about themselves. And so, it was with great joy that we received two books about physicians who helped shape the course of American Medicine.

"The Man Who Lived for Tomorrow— A Biography of William Hallock Park, M.D.," is a delightful biography of the man who, among other great accomplishments, saved the lives of thousands of children by his diphtheria antitoxin. Park did other important things in his life; his innumerable discoveries earned him a place among the immortals in Medicine. This is no place to review the highlights of the work. Wade Oliver, for many years a well known teacher of bacteriology, the author of two volumes of poems and of a delightful small volume, "Stalkers of Pestilence," has written an absorbing, moving, and all in all a delightful biography. Not only will it prove invaluable to future medical historians, but merely as a book to pick up and read it will be found a thing of pleasure.

Simon Flexner and James Thomas Flexner offer "William Henry Welch and the Heroic Age of American Medicine." Simon Flexner was one of Welch's early pupils and was closely associated with his former teacher through most of his life. James Thomas Flexner, son of Simon Flexner, will be recognized for his widely read early American history, "Doctors on Horseback."

Welch needs no introduction to any one of our profession. He was one who lived in our time and whose life and work will be read about and discussed a century from now. A many-sided figure, "Popsy" truly was a character. And the Flexners have done an honest and detailed portrait of this man who was the intellectual father of so many of the greatest scientists in America. We would not venture to predict the work's reception by the average lay reader but we do predict that the Doctor of Medicine will find every chapter good reading.

This is the Holiday Month, the time one exchanges gifts with relatives and friends. Doctors often make gifts of books. This year we recommend these two volumes as just the gift for a colleague or a co-worker. They are the type of books one feels proud to have on the shelves of his library.

Original Articles

JUVENILE OSTEOCHONDREAL (CHONDRO-EPIPHYSITIS) HYPOTHYROIDISM

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FROM a former study[1] it is the authors' contention that so-called juvenile chondro-epiphysitis is due to neither an inflammatory process nor vascular changes but specifically to hypothyroidism with the consequent lack of its tissue differentiating factor. The confusing terminology of proper names as related to the various joints involved which designate each as a separate clinical entity should be done away with entirely, and the term "chondro-epiphysitis" changed to "osteochondreal hypothyroidism." Basic therapy, we believe, is adequate replacement of desiccated thyroid. Orthopedic treatment, frequently necessary, is adjunctive.

In our former publication such characteristic chondro-epiphyseal changes were found in ninety-one out of 258 clinically proved endocrinopathic patients. Out of this ninety-one all but five were associated with the primary or secondary signs of hypothyroidism, such as mental retardation, characteristic structural changes, delay in the time of appearance of osseous centers, increased blood cholesterol and decreased basal metabolic rates. Thirty-eight patients, or 41 per cent, revealed multiple epiphyseal disturbances. This indicates its generalized character. The following endocrine diagnoses were noted: thirty cases of hypothyroidism, thirty-five cases of adiposogenital pituitarism, twenty-five cases of pituitary dwarfism and one case of eunuchoidism. The osseous findings were made possible through the routine roentgenographic study for osseous development. We deem this a most important diagnostic procedure in endocrine medicine. In a control group of ninety-nine non-endocrine patients in the same age group only 7 per cent revealed comparative Roentgen findings of chondro-epiphyseal disturbance. Only two of the endocrine patients cited had associated clinical symptoms of so-called juvenile osteochondritis.

The requirements for the diagnosis of hypothyroidism, either primary or secondary, are the usual ones: clinical history, developmental delay, decreased basal metabolic rates well below minus 10 per cent, increased blood cholesterol above 200 mg. per 100 cc. blood, and delay in osseous development. In addition, we now include chondro-epiphyseal changes as indicated in this publication. Because of the complexity of the entire endocrine mechanism uniglandular disturbances are comparatively rare. The present trend in diagnosis is pluriglandular as is the treatment. Therefore, by primary hypothyroidism is meant a clinical disturbance in which no signs of dysfunction can be determined except those referring to the thyroid. By secondary hypothyroidism we imply that the primary failure is due to a gland other than the thyroid, such as primary pituitary failure exhibiting growth or sex disturbance together with associated determinable signs of thyroid failure. Characteristic chondro-epiphyseal changes are not infrequently seen roentgenologically in a normally con-

stituted, growing child. We believe this is a sign of poor thyroid function which has prevented proper epiphyseal differentiation. Therefore, regardless of the clinical syndrome met with all patients exhibiting such characteristic bone changes should be considered as definitely hypothyroid and treated with desiccated thyroid to bring about normal bone differentiation.

To make our observations more conclusive, we are presenting in this publication twenty-seven patients. All showed chondro-epiphyseal changes associated with clinical symptoms such as pain and impairment of function. The Roentgen diagnoses in this study in all but a few instances were made by a cross-section of able roentgenologists in our area. It can be stated in this regard that in the original study our roentgenological evidence represented more advanced changes than in many of the cases in which specific chondro-epiphyseal changes were diagnosed in this present group. Had we followed these lesser roentgenologic signs in the original study, the percentile incidence would have been greatly increased. Because of the associated local symptomatology plus the unbiased Roentgen diagnoses there can be no doubt that in this group we are dealing with heretofore so-called clinical chondro-epiphysitis. A therapeutic response, shortening of the invalidism, and the return to normal bone detail through adequate thyroid therapy, we believe, is definite clinical evidence of the aforementioned contention.

CASE REPORTS

Perthes' Disease. CASE I. Unilateral. J. W., adiposgenital pituitary type, age five years, was mentally retarded.

In March, 1934, the patient complained of pain in the left hip. The duration was seven weeks. The limp affected the left side. There was normal function of the hip except for restriction to internal rotation. X-ray examination revealed "advanced osteochondritis juvenile deformans, left side." (Dr. H. A. Jarre, Grace Hospital.) Basal metabolic rate was minus 35 per cent.

The patient was allowed to be ambulatory with the use of crutches, and he constantly bore weight on his left leg. He was placed under thyroid therapy, and at the end of two months the pain in the hip had disappeared. Follow-up x-ray in June, 1938, showed "healed Perthes' disease of the left hip." (Dr. H. A. Jarre.) The Roentgen report of June, 1939, was "osteochondritis juvenilis deformans of the proximal femoral epiphysis, healed; some shortening and broadening of the femoral neck; mild coxa vara." (Dr. H. A. Jarre.)

Clinical examination in August, 1939, revealed normal function of hip and no limp. Duration of thyroid treatment was approximately four years with an average dose of $3\frac{1}{2}$ gr. daily. Basal metabolic rates ranged from minus 35 per cent up to minus 18 per cent, minus 6 per cent, plus 15 per cent and plus 6 per cent.

CASE II. Bilateral. B. P., adiposogenital pituitary type, age five years. In November, 1936, the patient complained of pain in the left hip and thigh. Twenty months previous he fell in the school gymnasium, but recently the pain had increased and the limp had become more noticeable. Examination presented a limp affecting the left side. The left hip revealed normal function except for restriction to internal rotation. The right hip showed normal range of motion and no subjective symptoms. Report of the x-ray of the pelvis was "flattening of the epiphyseal portion of the left upper femur indicating an osteochondritis; fragmentation is present; right hip shows similar changes but not so marked." (Dr. C. C. Birkelo, Herman Kiefer Hospital.) Basal metabolic rate was minus 26 per cent.

The patient was ambulatory with the use of crutches and he was allowed to walk as much as he desired. He was placed under thyroid therapy and at the end of two months there was complete disappearance of pain. Follow-up x-ray taken in January, 1937, showed "bilateral osteochondritis juvenilis deformans, apparently in the state of repair on the right hip while much more active and in the state of progressive destruction on the left hip." (Dr. H. A. Jarre.) A report in May, 1937, was "bilateral osteochondritis juvenilis deformans of the left hip in the state of repair with some flattening and broadening of the femoral neck; healing identical disease of the right hip; left hip undergoing repair." (Dr. H. A. Jarre.) The

x-ray report, December, 1938, showed "the disease in the right hip essentially healed. The process in the left hip still appears to be in the

where there is a flattening of the upper femoral epiphysis itself, associated with fragmentation and rarefaction of the epi-
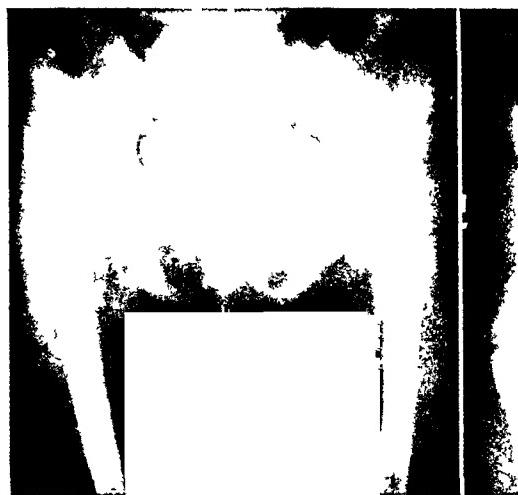
Fig. 1. Beginning of treatment.
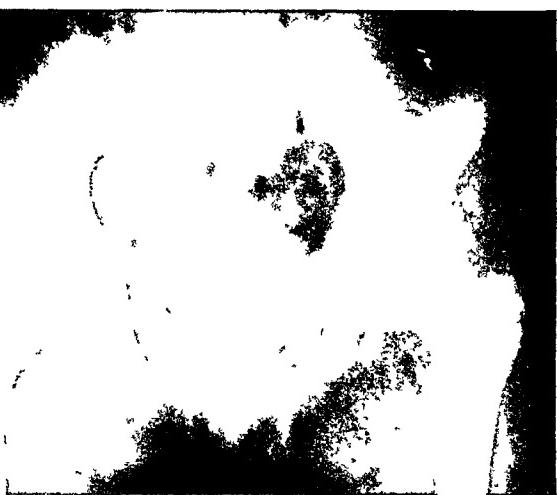
Fig. 2. Final film, five years later.

Fig. 3. Beginning of treatment.
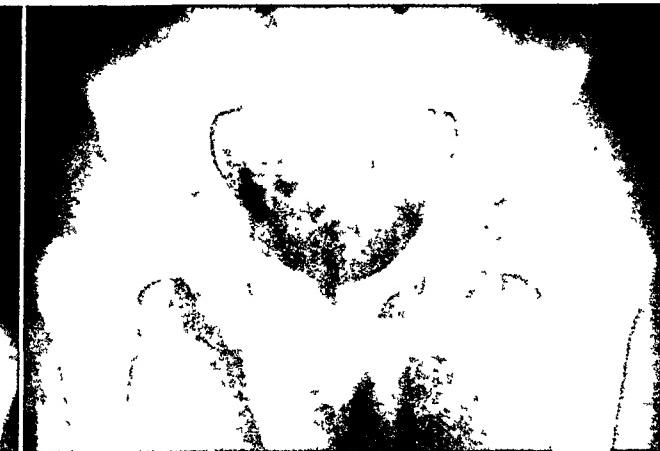
Fig. 4. Twenty-nine months later.

process of repair." (Dr. H. A. Jarre.) In June, 1939, the x-ray report was "osteochondritis deformans juvenilis left hip, in the state of repair, with some flattening of the head and neck." (Dr. H. A. Jarre.)

Clinical examination in August, 1939, revealed a normal gait and no evidence of a limp. The right hip had normal functional range. The left hip had slight restriction to internal rotation. The left leg measured 28½ inches and the right, 28⅝ inches. The duration of thyroid treatment was two years and seven months with an average dose of 2½ gr. daily. Basal metabolic rates ranged from plus 15 per cent in April, 1937, to minus 5 per cent in June, 1937, and minus 4 per cent in August, 1939. (Figs. 1, 2, 3 and 4.)

Discussion. Perthes' disease is usually recognized as a condition found in the hip

physeal head and widening of the neck of the femur. The former orthopedic procedures in Perthes' disease have been bed rest and immobilization with plaster or traction for various periods of time, frequently from one to three years. Operative procedures to hasten recovery and revascularization such as drilling of the upper femoral epiphyses have been advised.[2,3]

It is the writers' contention that with early recognition of juvenile osteochondritis of the hip and adequate thyroid therapy, radical operative procedures and immobilization can be avoided.

Slipped Upper Femoral Epiphyses. CASE III. Bilateral old slipped femoral epiphysis., D. Mc., colored, age fourteen years. In May, 1938, the patient complained of pain in the right hip and

about the pelvis. The duration was three years. Examination presented a limp affecting the right side. The hip showed moderate limitation

seen by a general surgeon who had applied a plaster cast in the position of abduction to the right hip. Examination following removal of the

FIG. 5. Beginning of treatment.

FIG. 6. Sixteen months later.

of flexion, good abduction and slight limitation to internal rotation. The left hip presented a good range of flexion, abduction and rotation. Both legs were of equal length.

X-ray report in May, 1938, was: "Bilateral coxa vara, somewhat more marked on the right side than on the left, with mild osseous proliferation from the level of the proximal femoral epiphyses, and the circumference of the right acetabular roof. This deformity we believe to be the result of slipping of the femoral epiphyses. Fusion of the femoral epiphyses is not complete." (Dr. H. A. Jarre.) Basal metabolic rate was minus 14 per cent in May, 1938. X-ray taken in May, 1939, showed "bilateral healed slipped femoral epiphyses producing mild coxa vara deformity." (Dr. H. A. Jarre.) X-ray in September, 1939, showed "bilateral coxa vara more marked on the right than on the left. The femoral epiphyses are now firmly fused." (Dr. H. A. Jarre.)

No treatment other than thyroid therapy was given. The average dose was $2^1{}_2$ gr. daily. At the end of four months all pain had disappeared. Clinical examination in September, 1940, revealed no definite limp. Flexion of the right hip was present to right angles. There was good range of abduction and slight limitation to internal rotation. X-ray taken September, 1940, presented "No material change since the report of September, 1939." (Dr. H. A. Jarre.)

CASE IV. J. G., white, age fourteen years, Fröhlich's type. In July, 1940, the patient complained of a limp and pain in the right hip. The duration was two years. He was previously

cast presented an obese boy with a limp affecting the right side. Flexion of the hip was present to right angles. Moderate external rotation of the leg was noted. Limitation of internal rotation was present. Basal metabolic readings ranged from minus 12 per cent in July, 1940, to plus 14 per cent in December, 1940.

In May, 1940, two months previous to orthopedic examination, x-ray of the patient was taken in the cast room with the leg in position of abduction. The report was: "A correction of the slipped upper femoral epiphysis was seen in the film study made outside this hospital. Fusion of the epiphysis is not present." (Dr. W. A. Irwin.) The patient was placed on an average dose of 3 gr. of desiccated thyroid daily. No further immobilization was used. He was ambulatory on crutches but bore some weight on his leg. X-ray report, August, 1940, showed "a partial slip of the upper epiphysis of the right femur with the diaphysis being displaced slightly anterior and with the metaphysis being widened anteriorly." (Dr. W. A. Irwin.) X-ray report, September, 1940, demonstrated "an irregular and notched area in the upper anterior bodies of the vertebrae. This could be considered as a case of epiphysitis of the spine." (Dr. W. A. Irwin.) X-ray report, December, 1940, compared with the study made in September, 1940, failed to demonstrate any change in the relationship of the diaphysis and the epiphysis of the right femur. *"Fusion of the epiphyseal line is now present."* (Dr. W. A. Irwin.)

Clinical examination in December, 1940, presented a child who walked with a right-sided limp. No real external rotation of the leg was present. The right hip showed flexion to right angles. Internal rotation was limited. Abduction was of good range but moderately limited. (Figs. 5 and 6.)

Discussion. Slipped upper femoral epiphyses is a condition in which there is an apparent weak union between the epiphysis itself and the neck of the femur, resulting in a displacement of the head with the neck. It is also spoken of as an ante-version of the neck on the head.[4] Treatment in slipped upper femoral epiphyses has been varied, including radical surgical procedures. This latter still remains an orthopedic measure of definite value. Manual reduction,[5] insertion of a nail,[6] drilling through the epiphyseal plate, and insertion of small grafts[7] have also been recommended, along with immobilization in plaster. While our data on slipped upper femoral epiphyses are still very meager, the writers are of the opinion that with early recognition of slipped upper femoral epiphyses and adequate thyroid therapy, more rapid and more complete fusion of the epiphyseal line may take place, and, therefore, subsequent radical operative procedures may possibly be avoided.

Osgood Schlatter's Disease. CASE V. Bilateral, N. L., age thirteen years. In August, 1938, the patient complained of pain in the right knee. The duration was two months. The pain was present when walking or moving the knee. There was no history of injury. The right upper tibia presented a prominent tubercle with definite pain on pressure over this tibial tubercle and patellar tendon. The left upper tibia showed a moderately enlarged tibial tubercle but there was no pain. X-ray examination of both knees in the lateral projection revealed "a bilateral irregularity in shape and texture of the tibial tubercle, which we believe to be due to a bilateral Osgood Schlatter's disease." (Dr. A. K. Payne, Grace Hospital Clinic.) Basal metabolic rate was minus 14 per cent.

The patient was placed on thyroid therapy. The average daily dose was 2½ gr. Pain in the knee ceased at the end of three months. Basal

metabolic rate in April, 1939, was minus 6 per cent and in August, 1939, it was minus 25 per cent. Thyroid therapy was increased. X-ray in June, 1939, revealed "Definite improvement in the Osgood Schlatter's disease." (Dr. H. A. Jarre.) In July, 1939, the report was "healed Osgood Schlatter's, left, but there is still a transverse fissure present through the proximal end of the right tibial tubercle." (Dr. E. M. Shebesta, Grace Hospital.) Final x-ray in August, 1939, showed complete healing. (Dr. Jarre.)

CASE VI. Bilateral, W. B., structurally normal type, age eleven years. There was delay in academic progress. In March, 1938, the patient complained of having had pain of increasing intensity in both knees for seven weeks. It was aggravated when he participated in sports and when he rode a bicycle. Examination showed bilateral prominent tibial tubercles and bilateral tenderness over the tubercles and patellar tendons. The maximum amount of tenderness was over the tubercles. X-ray taken in March, 1938, revealed "Fragmentation of the right tibial tubercle having the characteristic appearance of Osgood Schlatter's disease. More limited changes involving the left tibial tubercle." (Evans and Reynolds.) Basal metabolic rate was minus 7 per cent.

The patient was not immobilized. He was placed under thyroid therapy and after one month the pain in both knees disappeared. Basal metabolic rate was minus 7 per cent in November, 1938, and plus 1 per cent in August, 1939. The average dose of desiccated thyroid was 2½ gr. daily. X-ray report in January, 1939, was "Definite reformation of the right tibial tubercle with no fragmentation present. Left knee chiasm between the tubercle and tibial shaft rather wide. There is marked improvement over the condition observed in plates taken in March, 1938." (Dr. Gerald Bernath.) X-ray in August, 1939, revealed complete healing in both tibial tubercles. (Dr. Bernath.)

CASE VII. Unilateral, J. H., problem child, moderately obese, age twelve years. In February, 1939, the patient complained of pain in the right knee which had been present for five months. The pain increased when walking and running. Examination presented marked tenderness over the right upper tibial tubercle. X-ray taken February, 1939, revealed "the right tibial tubercle to be definitely shorter than

on the left; poor radiability; fairly wide chiasm but no fragmentation." (Dr. Gerald Bernath.) Basal metabolic rate was minus 5 per cent.

The patient was not immobilized. Four months following the initiation of thyroid therapy all pain ceased and he was allowed to resume sports, such as hockey. The average dose was 2 gr. daily. Basal metabolic rate in August, 1939, was minus 1 per cent. He did not return for x-rays because he had no symptoms.

CASE VIII. Unilateral, R. O., adiposogenital pituitary type, age twelve and one-half years. In April, 1937, the patient complained of having had pain in the right knee for one month. The pain was more marked when running and kneeling. Examination presented fullness over the right tibial tubercle with pain on palpation. Weight one year previous was 97 pounds. Weight at the time of examination was 123 pounds. Report of x-ray of both knees April 12, 1937, was: "The films reveal an Osgood Schlatter's disease involving the right tibial tubercle with some soft tissue swelling about the tubercle." (Evans and Reynolds.) Basal metabolic rate was minus 15 per cent.

The patient was not immobilized. One month following institution of thyroid therapy pain in the knee disappeared. She received an average dose of 2½ gr. of desiccated thyroid daily from April to October, 1937. Basal metabolic rate in July, 1939, was minus 3 per cent.

X-ray in September, 1937, revealed "definite improvement of the appearance of the tibial tubercle of the right knee." (Evans and Reynolds.) X-ray report in July, 1939, stated that there was a normally appearing tibial epiphyseal tubercle. (Dr. Gerald Bernath.)

CASE IX. Bilateral, E. L., fairly normal type, age thirteen years. In January, 1939, the patient complained of having had severe pain in the left knee for one year. Recently he had occasional ache in the right knee. Pain was noticed especially when walking or climbing stairs. Examination showed a very prominent tibial tubercle on the left side which was extremely tender to touch. Tenderness was present over both the tibial tubercle and the patellar tendon. The right knee presented no unusual prominence but there was tenderness to palpation. X-ray report, January, 1939, of both knees was: "There is considerable fragmentation of left tibial tubercle. It appears to be lifted from the shaft of the tibia proper. Soft tissue swelling present over this region. The

right tibial tubercle is moderately lifted, but there is no fragmentation. Summary—Osgood Schlatter's disease, bilateral." (Dr. Gerald Bernath.) Basal metabolic rate was minus 13 per cent.

Due to the severity of pain the left knee was immobilized but only for two weeks. There was a marked decrease in symptoms during the first month of thyroid therapy. At the end of three months all symptoms disappeared. Average dose was 3 gr. daily. Basal metabolic rate in July, 1939, was plus 1 per cent.

X-ray report in May, 1939, was: "Left knee; the fragmented portion of the tibial tubercle has united. There is still some irregularity present. There also appears to be some union of the tongue of the tubercle to the shaft of the tibia. Right knee shows some improvement in the relationship of the tibial tubercle to the shaft. Summary; improving bilateral Osgood Schlatter's disease." (Dr. Gerald Bernath.) X-ray report in July, 1939, was "Some further improvement in the left tibial tubercle, but still incomplete reformation. Right knee shows no apparent changes." (Dr. Gerald Bernath.)

Since the early part of June, 1939, four months following the original examination, the patient has been participating in all sports and there has been no recurrence of any symptoms.

CASE X. Unilateral, R. S., structurally normal type, age eleven years. In September, 1936, the patient complained of having had pain in the left knee for three months, particularly on bending or kneeling. Examination revealed definite tenderness over the left tibial tubercle. Report of x-ray in September, 1936, was "Left knee shows definite lifting of tibial tubercle and broad chiasm between the shaft and tubercle." (Dr. Henry Ulbrich.) Basal metabolic rate was minus 15 per cent.

Two months following institution of thyroid therapy all symptoms disappeared. The average dose was 2 gr. a day. The patient moved to another city and follow-up could not be obtained.

CASE XI. Unilateral., O. D., structurally normal type, age twelve years. In April, 1938, the patient complained that for one year she had been having pain in the left knee. Examination presented a prominent left tibial tubercle with tenderness. X-ray in April, 1938, showed "Definite chiasm between the tubercle and tibial shaft. No fragmentation." (Dr. H. A. Jarre.) Basal metabolic rate was minus 9 per cent.

Three weeks following initiation of thyroid therapy all pain had disappeared. Average dose was 1⅓ gr. daily. X-ray taken in June, 1939, revealed "No apparent disease at or near the left knee." (Dr. H. A. Jarre.)

CASE XII. Unilateral, J. D., hypothyroidism, age fifteen years. In February, 1935, the patient complained of recurrent unaccountable headaches and of having had pain in the left knee for five months. He had fallen from his bicycle and developed what was termed a traumatic synovitis. He had been treated orthopedically with immobilization and rest. The pain was recurrent except when immobilized. Examination revealed slight swelling of the left knee. There was tenderness over the region of the tibial tubercle. X-ray examination February 26, 1935, showed lipping of the tubercle plus evulsion such as is seen in Osgood Schlatter's disease. Basal metabolic rate was minus 13 per cent.

The patient was placed on desiccated thyroid in a dosage varying from 1 to 3 gr. daily. After a period of one month no further pain was complained of even though all normal activities were permitted. There was no recurrence of headaches. On May 10, 1935, x-ray of the knee still revealed separation of the tubercle but to a much less degree. X-ray on October 26, 1935, showed the tubercle of the tibia to be completely fused. Basal metabolic rates ranged from minus 24 per cent to plus 2 per cent.

CASE XIII. Bilateral, G. G., hypothyroparathyroidism, age thirteen years. In March, 1937, the patient complained of having had pain in both knees for one month. Examination revealed tenderness over the tibial tubercles. There was no swelling. X-ray showed fragmentation of tibial tubercles and irregularity of diaphyses (Osgood Schlatter's disease). Basal metabolic rates were minus 9.6 per cent and minus 16.1 per cent.

The patient received desiccated thyroid in an average daily dose of 2 gr. Following institution of this therapy no further complaint of pain was noted. X-ray April 8, 1938, revealed normal osseous structures of the right tubercle; areas of very slight fragmentation in the left tubercle, completely normal bone detail of the diaphyses.

CASE XIV. Bilateral, J. S., age twelve years. In December, 1939, the patient complained of having had pain in both knees for three months. Examination revealed prominent bilateral tibial

tubercles. Marked tenderness was present over both tibial tubercles. Pain was increased by knee flexion and riding a bicycle. X-ray taken
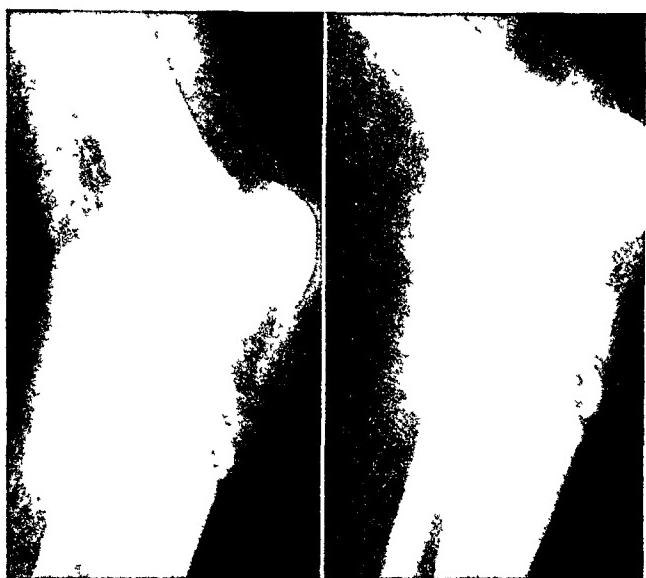
FIG. 7. Beginning of treatment.   FIG. 8. Ten months later.

December 2, 1939, revealed multiple bone centers, that is, fragmentation of both tibial tubercles. No definite bone or soft tissue inflammatory reaction was noted. (Dr. H. L. Ulbrich.) X-ray taken February 8, 1940, revealed fragmentations of the epiphyses at the tibial tuberosities with no evidence of any soft tissue swelling or density. (Dr. Ulbrich.) X-ray taken September 5, 1940, showed no evidence of soft tissue swelling. The tibial epiphyses were becoming one piece. The different centers were uniting. (Dr. Ulbrich.) X-ray taken December 3, 1940, revealed no demonstrable fragmentation of the tubercles or epiphyses. The density and bone detail in both instances were normal. (Dr. Ulbrich.)

The basal metabolic rate was minus 10 per cent. The patient was placed on desiccated thyroid in December, 1939, and the dosage varied from 1 to 4 gr. daily. Two months following institution of thyroid therapy the pain in both knees ceased. The patient has been participating in all activities such as roller skating and ice-skating since the third month of medication. (Figs. 7 and 8.)

Discussion. So-called Osgood Schlatter's disease is probably the most frequent of the chondro-epiphyseal disturbances. The outstanding complaint is pain. The previously recommended orthopedic treat-

ment was that of immobilization in plaster until the pain ceased or until sufficient ossification had taken place. Open operations[7,8] on the tibial tubercle also were advised in order to produce coalescence of fragmentation and to hasten ossification between the tubercle and the shaft.

Immobilization was not employed in nine of the ten patients cited. They were all normally ambulatory. There was no interference with school and play life. The relief from pain was much more prompt than with the older method of immobilization. While the number of patients is not great, we firmly believe that the return of normal bone detail roentgenologically was definitely hastened as compared with the older methods of treatment.

Apophysitis. Case xv. Bilateral, J. E., hypothyroid type, age eight years. In July, 1938, the patient complained of having had pain in both heels and a tendency to limp for the previous eight weeks. The pain had been constant and was increased especially after running. Examination presented a rigid foot limp due apparently to an effort to take the strain off the tendo achilles. Both feet showed normal range of function. All muscles were active and of good strength. There was marked tenderness to palpation over the posterior portion of the right os calcis near the insertion of the tendo achilles. Report of the x-ray in July, 1938, was: "Much irregularity and serration of the posterior portion of the right os calcis and a fragmented epiphysis. The left os calcis showed considerable irregularity and rarified epiphysis." (Dr. Ulbrich, Mount Clemens.) X-ray in June, 1939, showed "still further improvement in the epiphysis of the left os calcis and marked improvement in the contour of the posterior end of the body of the os calcis. Right showed identical improvement." (Dr. Ulbrich.)

The patient displayed early improvement and six months following the institution of thyroid therapy all symptoms disappeared. Average dose was 3 gr. daily. In June, 1939, the patient walked without any limp. He was very active on the farm where he lived.

Case xvi. Bilateral, D. B., adiposogenital pituitary type, age twelve years. In April, 1939, the patient complained of having had pain in both heels for eight months. The pain was con-

stant when he was on his feet. He was previously hospitalized in one of the large hospitals and placed in plaster. Following discontinuation of this treatment pain again returned and became just as severe as formerly. Examination presented a bilateral limp. The right foot revealed very marked tenderness at the posterior end of the os calcis at and just below the insertion of the tendo achilles. On the left foot there was definite pain at the posterior end of the heel near the insertion of the tendo achilles. X-ray report in April, 1939, was: "The epiphysis of the right os calcis is very irregular. Fragmentation is present at the lower end of the epiphysis. There is a small accessory navicular on the left. Diagnosis: Apophysitis of each os calcis more marked on the right; elongated scaphoid on right; accessory scaphoid on the left." (Dr. G. J. Bernath.) Basal metabolic rate was minus 37 per cent.

The patient was not immobilized. Eight weeks after initiation of thyroid therapy all symptoms disappeared. The average dose was 2 gr. daily. Basal metabolic rate in August, 1939, was plus 1 per cent. X-ray report in August, 1939, was: "Left, marked improvement in the development of this epiphysis. Serration previously present is not nearly so marked. No fragmentation. Right, the marked irregularity previously present at the posterior end of the os calcis has almost completely disappeared. Fragmentation is greatly improved. There is still one transverse fissure present in lower portion of the epiphysis." (Dr. G. J. Bernath.) The patient at this time presented a normal gait. He was able to run and participate in all games. He was very active at camp.

Case xvii. Bilateral, T. McG., structurally normal type with cryptorchidism, age ten years. In May, 1939, the patient complained of constant pain in the left heel and occasional pain in the right heel. This had been present for three weeks. He could not run. Examination revealed a limp affecting the left side. The left foot showed marked tenderness at the posterior end of the os calcis at and just below the insertion of the tendo achilles. The right heel presented a moderate amount of tenderness at the posterior portion of the os calcis. Studies of both os calces in May, 1939, showed the following: "There is some serration of the apophyses at the posterior portion of each os calcis. The left os calcis shows fragmentation at its lower end. The right os calcis shows what appears to

be beginning fragmentation at its lower end." (Dr. G. J. Bernath.) Basal metabolic rate was minus 23 per cent in May, 1939.

provement in the density of the left os calcis epiphysis. Serration is not so marked as on previous films. Lines of density diminished,

FIG. 9. Beginning of treatment.　　FIG. 10. Eighteen months later.

Five weeks after institution of thyroid therapy the patient was completely free of all symptoms and participated in games. Basal metabolic rate in August, 1939, was minus 9 per cent, and on January 9, 1940, it was minus 7 per cent. X-ray in August, 1939, revealed "Definite improvement in the body of the epiphysis of the right os calcis. Fragmented area has definite filling in. Left os calcis shows marked disappearance of serration and complete disappearance of the lower fragmented area." (Dr. G. J. Bernath.)

CASE XVIII. Bilateral, R. S., structurally normal type, age ten years. In June, 1939, the patient complained of having had pain in both heels for one year. Examination revealed a mild bilateral pronation of both feet. The left foot presented definite tenderness to palpation at the posterior portion of the os calcis at and below the insertion of the tendo achilles. The right heel presented tenderness in the same location but not so marked. Studies of both os calces in June, 1939, showed "epiphyseal lines of both os calces are serrated. There are lines of diminished density extending through the left apophysis. Similar, less obvious lines extend through the upper portion of the right apophysis." (Dr. G. J. Bernath.) Basal metabolic rate was minus 8 per cent in June, 1939.

Five weeks following institution of thyroid therapy the heel pain ceased. Average dose was 1½ gr. daily. At this time the patient left on vacation and the medication was stopped. X-ray in July, 1939, revealed "Definite im-

show improved density. The epiphysis of the right os calcis shows increased density throughout the entire body of this right epiphysis and less serration." (Dr. G. J. Bernath.) The end of the os calcis still showed some tenderness to palpation. There was no complaint when walking. Thyroid therapy was re-established.

Examination on August 7, 1939, revealed moderate tenderness to palpation. The patient did not complain when walking and running. Duration of observation was two months.

CASE XIX. Bilateral, J. M., pituitary dwarf, age seven years. In April, 1939, the patient complained of having had pain in both heels for seven weeks. Clinical examination presented some pronation of each foot. There was definite tenderness to palpation at the posterior, lateral and medial aspect of each os calcis. Tenderness was more marked on the left. X-ray in April, 1939, showed "marked fragmentation of the apophyses of each os calcis. Epiphyseal line is serrated and irregular. The changes are those of an apophysitis." (Dr. G. J. Bernath.) Basal metabolic rate was minus 16 per cent.

Following five weeks of thyroid therapy all subjective signs subsided. The average dose was 1½ gr. per day from April to June. He did not return for follow-up for several weeks. In July, 1939, he presented no subjective symptoms, but there was definite tenderness to palpation of the epiphysis of each os calcis. X-ray report was "each os calcis still shows fragmentation of each epiphysis." (Dr. G. J. Bernath.) The patient still requires thyroid therapy.

CASE XX. Bilateral, W. H., adiposogenital pituitarism, age twelve years. On August 22, 1939, the patient's chief complaints were pain

ease, is very common. With or without treatment the ultimate prognosis is usually good. The pain, however, is a frequent

FIG. 11. Beginning of treatment.   FIG. 12. Eighteen months later.

in both heels, genital hypoplasia and obesity. Since attending gymnasium class for the previous three years he had complained frequently of pain in both heels. It had been worse, however, for the preceding few months when he walked or bore his weight for any length of time. He was forty pounds above the maximal normal and his height was at the upper limit of normal. The penis was about the size of a five year old child. While the testicles were descended into the scrotum, they were soft in consistency and definitely hypoplastic. There was tenderness over both heels. X-rays of the elbow and ankles presented a chondro-epiphyseal disturbance in the trochlea and evidence of fragmentation of both os calces. Changes were more marked in the left heel. Basal metabolic rate was minus 4 per cent. Blood cholesterol was 210 mg. per 100 cc. blood.

The patient was placed on desiccated thyroid, gr. 3 daily, and the anterior pituitary sex-like hormone, 3 cc. twice weekly. The pain in the heels definitely subsided one month after institution of treatment and he was allowed to play football. The genital hypoplasia and obesity were corrected. There has been no further complaint. Follow-up x-rays were not obtained as the mother deemed the patient quite well when seen one year later. (Figs. 9, 10, 11 and 12.)

Discussion. Epiphyseal disturbance of the os calcis, like Osgood Schlatter's dis-

cause for immobilization and loss of school and play time. In the six patients cited no immobilization was deemed necessary. The outstanding symptom, pain, was much more rapidly relieved by desiccated thyroid than by the older methods,[10,11] and the return to normal bone detail roentgenologically was much faster.

Köhler's Disease. CASE XXI. P. G., generalized chondro-epiphyseal disturbance, pituitary dwarf, secondary hypothyroidism, age eleven years. The patient was first seen January 18, 1932. His chief complaint was lack of statural growth. His standing height was 5.8 inches below the minimal normal. All other measurements were comparatively below the minimal normal, conforming with the diagnosis of true pituitary dwarfism. In addition he presented clinical signs of secondary hypothyroidism: alabaster type of pallor, dry skin, and a relative bradycardia. Secondary anemia was evidenced by a red blood cell count of 3,500,000. Basal metabolic rates were minus 29 and minus 30 per cent. X-rays taken January 23, 1932, of the knee, elbow, wrist, shoulder, hip and ankle gave a bone age delay of fully three to four years. All developing osseous centers revealed chondro-epiphyseal changes. The ankle displayed marked Roentgen signs of Köhler's disease. Dr. Lewis Clark Wagner, New York, was called in consultation, and he confirmed

the above Roentgen findings plus a marked degree of flat foot for which he recommended orthopedic shoes. It was his opinion that the generalized chondro-epiphyseal disturbance was endocrine in origin. These films were also reviewed at that time by the roentgenologists at the Ruptured and Crippled Hospital, New York, who concurred in general with the above findings.

The following treatment was administered: desiccated thyroid in a tolerant dose varying from 2 to 4 gr. daily; injections of the growth hormone in the form of antuitrin-G, 2 to 5 cc. twice weekly. Check-up films of the same joint regions taken April 11, 1932, revealed no marked change in the chondro-epiphysitis present. There was, however, a definite advance in the osseous development. X-rays taken January 24, 1933, and August 2, 1933, showed definite improvement of the chondro-epiphyseal disturbance. X-rays of April 10, 1932, displayed almost complete healing of what was previously termed Köhler's disease. There was marked improvement in both osseous development and the pathological changes first noted. Treatment and observation were continued until March, 1937, at which time the x-rays revealed normal osseous development and normal bone detail. His height was 63.2 inches which was 2 inches above the minimal normal. Adolescence was then occurring normally together with epiphyseal closure. Treatment was withdrawn. At the present time he is an average-sized young man and sex development has been normally completed.

CASE XXII. R. M., hypothyroidism, age five years five months. The patient was first seen January 11, 1930. His chief complaints were obesity, physical sluggishness, marked flat foot and difficulty in running. His weight was ten pounds above the maximal normal and his height was just below the maximal. Basal metabolic rates were not obtained. The diagnosis of hypothyroidism was based on the clinical findings of his generalized obesity, physical inactivity, dry skin with subcutaneous thickening and suggestive hypothyroid pallor. X-rays of the wrist, elbow, knees, ankles and hip displayed a delay in osseous development of slightly over one year. Chondro-epiphyseal changes were noted in both ankles. The scaphoid, both internal cuneiforms and the heads of both second metatarsals exhibited marked irregularity in osseous detail. They were moth-

eaten and ragged in appearance. The heads of the third metatarsals exhibited the same change but to a less degree. There were sugges-

FIG. 13. Left, beginning of treatment; right, fifteen months later.

tive changes in the left scaphoid. The Roentgen diagnosis was bilateral Köhler's disease.

A proper orthopedic shoe was prescribed for the patient. Desiccated thyroid was given in a tolerant dose varying from 3 to 4 gr. daily. Comparative films of both ankles taken May 14, 1930, showed improvement of the so-called Köhler's disease, but the changes were still definite. X-ray of both ankles made September 20, 1930, revealed that the former evidence of Köhler's disease had almost entirely cleared. There was still some slight irregularity of the third and fourth metatarsals, but the rest of the osseous structures showed normal roentgenographic bone detail. (Fig. 13.)

Discussion. Two cases of Köhler's disease are described because of the advanced Roentgen picture and disturbance of gait. Both presented bilateral involvement. It is most probable that more radical treatment would have been given had these patients sought usual orthopedic care. In the first case presented there was complete return to normal bone detail roentgenologically with thyroid therapy. The second is still under treatment but according to the x-rays he, too, is approximating normal bone detail.

Former orthopedic procedures include immobilization[12,13] with occasional indication for arthrodesis, osteotomy and excision of the involved heads of the bones even including excision of the related metatarsal

and phalanx. Despite this heroic treatment results were not always satisfactory.

Epiphysitis of the Spine. CASE XXIII. W. W., slipped upper femoral epiphysis, left, adiposo-genital pituitary type, age fifteen years. In April, 1939, the patient complained of having had pain in the left hip for six months. He had poor posture. There was no history of injury. Examination revealed a rather definitely obese individual walking with a left limp, the left leg being in marked external rotation. The spine showed a marked round back and increased lordosis. The abdomen was prominent. Slight left dorsal scoliosis was present. There was bilateral genu-valgus and bilateral pronated feet. Left hip had flexion to right angles and presented limited abduction and total loss of internal rotation. X-ray in April, 1939, revealed "Downward slipping and rotation of the femoral head of the left hip. Right hip negative. There is slight tilting of the pelvis, the left side being higher than the right. Diagnosis: slipped femoral epiphysis." (Dr. G. J. Bernath.) X-ray of the dorsal lumbar spine displayed: "Moderate scoliosis, convexity to the left, apex being at the eleventh to twelfth dorsal vertebra. In the lateral view is noted an irregularity of the epiphyses of all the dorsal vertebrae. There is irregularity of the articulating portions of these vertebrae. Summary of the spine x-ray: multiple epiphysitis." (Dr. Bernath.) Basal metabolic rate was minus 3 per cent.

The patient received desiccated thyroid in an average daily dose of 3 gr. X-ray in August, 1939, was reported as follows: "Dorsolumbar spine shows very little if any change since the last examination in April, 1939. X-ray of the pelvis taken the same date shows progressive slipping of the upper femoral epiphysis, left." (Dr. Bernath.)

Aching and fatigue in the spine disappeared two months following institution of thyroid therapy and postural exercises. The slipped femoral epiphysis was progressive. Examination of the left hip in August showed marked restriction of flexion, abduction and rotation. The leg was still in a position of marked external rotation. Replacement of epiphysis with nailing was performed September, 1939. Report of the x-ray of the spine December 14, 1940, was as follows: "Lateral views of the dorsal lumbar spine still show evidence of epiphysitis involving all but the first four dorsal vertebrae

and also involving the upper borders of the first two lumbar vertebrae. No further wedging of the dorsal vertebrae is noted." (Dr. E. M. Shebesta.)

Clinical examination in December, 1940, revealed that the posture of the individual had shown definite improvement. There had been no recurrence of aching or fatigue in the back. There was no increase in the spine curve. Left hip presented flexion restricted to slightly below right angles. There was no exterior rotation. Interior rotation was limited.

CASE XXIV. L. S., adiposogenital pituitary type, age thirteen years. In April, 1938, the patient complained of pain in the lumbar spine. He gave a history of slipping on some steps one month previous while in Arizona. Following this mild injury he complained of pain in the lower back. He was seen by an orthopedist who x-rayed his spine. A diagnosis of a fracture of the third lumbar vertebra was made, and the patient was placed in a plaster jacket with the spine in some hyperextension. Clinical examination revealed an obese boy with genital hypoplasia. X-ray forwarded from Arizona showed what appeared to be an irregular indentation of the upper anterior portion of the third lumbar vertebra. No definite compression was noted. Further study of these same films revealed some irregularity and small raised bodies about the upper lumbar and lower dorsal vertebrae. Because of the peculiar findings it was believed that this lesion might not be a fracture but part of a generalized epiphysitis of the spine. Tuberculosis was eliminated. He remained in his plaster jacket until May, 1938, and x-rays revealed absolutely no change in either the third lumbar vertebra or in the upper lumbar or lower dorsal spine. A diagnosis of multiple epiphysitis of the spine was made. In June an endocrine survey revealed a basal metabolic rate of minus 28 per cent.

The patient received desiccated thyroid in an average daily dose of 4 gr. The plaster jacket was discarded and no further support was used. All signs of backache disappeared even under normal activity. Follow-up basal metabolic rates were minus 17 per cent in December, 1938; minus 19 per cent January 9, 1939; minus 20 per cent January 14, 1939; and minus 15.2 per cent August 29, 1939.

Report of x-ray in July, 1938, was as follows: "The moth-eaten irregularity seen in the anterior portion of the third lumbar vertebra is

still apparent. However, there seems to be some improvement in the calcium deposition in this area. The zone of decalcification seems to be filling in. We also note irregularities about the site of the epiphyseal plates of the other lumbar vertebrae. These findings were not so clearly noted on previous examination. On the basis of this observation we are now inclined to believe that the pathology presents an epiphysitis." (Dr. G. J. Bernath.) X-ray taken October, 1938, showed "Slight improvement in the appearance of this condition." (Dr. Bernath.) X-ray in December, 1938, displayed "This condition appears to be the same as the last x-ray examination." (Dr. Bernath.) Report of x-ray in March, 1939, was: "There appears to have been some additional filling in through the upper anterior portion of the third lumbar vertebra. The vertebra is maintaining its normal shape and there is no evidence of wedging." (Dr. Bernath.) Report of x-ray in June, 1939, was: "The changes previously described in the upper anterior portion of the third lumbar vertebra shows marked improvement. There appears to be excellent filling-in in the upper anterior portion of this third lumbar vertebra. Summary: x-ray study shows definite improvement in filling-in of this moth-eaten irregular appearing area."

Follow-up report in August, 1939, revealed that there had been no pain in the lower back following the removal of the jacket and establishment of thyroid therapy. Activity in all games did not produce pain. Function of the back was normal. Obesity was reduced. The genital hypoplasia was corrected.

X-ray in October, 1940, of the dorsolumbar spine showed the vertebral epiphyses to be well healed. (Dr. Shebesta.)

CASE XXV. F. L. Immature type, age fourteen years. In March, 1939, the patient complained of poor posture of the spine and generalized aching in the back. Clinical examination presented left dorsolumbar, right lumbar curve with slight rotation. Report of x-ray in March, 1939, was as follows: "The anterior-posterior view showed slight curvature of the spine involving the dorsal and lumbar region. No marked rotation. Partial spina bifida from the twelfth dorsal to the fifth lumbar. Lateral view showed irregular punched-out areas of the upper anterior portions of the bodies of the third, second, and first lumbar vertebrae and twelfth, eleventh, and tenth dor-

sal vertebrae." (Dr. Ulbrich, Mount Clemens.) Basal metabolic rate was minus 4 per cent.

The patient received an average daily dose of 2 gr. of desiccated thyroid and was given postural exercises. At the end of two months he did not complain of pain in the back. He avoided treatment for a period of three months, and in August, 1939, his basal metabolic rate was minus 20 per cent. Thyroid therapy was re-instituted beginning with 1½ gr. per day. Report of x-ray taken in August, 1939, was the following: "Anteroposterior view of the spine shows a definite improvement over the films taken in March, 1939. The alignment of the dorso-lumbar spine is practically normal. However, there is still some irregularity over the upper anterior portion of the bodies of the upper lumbar and lower dorsal vertebrae. We believe that these epiphyseal changes in the spine are the cause of progressive scoliosis and are of endocrine origin." (Dr. Ulbrich.)

CASE XXVI. V. M., underweight, age seven years. In April, 1932, the patient complained of curvature of the spine. Examination showed a left dorsal, right dorsal lumbar curvature with rotation. X-ray showed a rather marked scoliosis in the dorsal and lumbar region, apex of the dorsal curve being in the mid dorsal region. There was some wedging of the bodies of the dorsal vertebrae. The patient was treated with suspension jackets, frame treatment with head, lateral and pelvic traction. Good correction of spinal deformity was obtained. The spine was then fused. Following the removal of plaster subsequent to spine fusion and application of brace, it was noticed that the deformity still was progressive. This may have been due to lack of complete fusion. She was not seen then for a period of months. Examination in 1935 showed a marked increase in the dorso-lumbar curve with marked increase in rotation. Basal metabolic rate was minus 35 per cent.

The patient was placed on thyroid therapy, believing that the progressive scoliosis plus the low metabolic rate was due to hypothyroidism. The average dose was 3 gr. daily. Basal metabolic rate was minus 5 per cent in December, 1938, minus 4 per cent in May, 1939, and minus 2 per cent in August, 1939. Follow-up x-rays at various intervals showed increasing deformity of the spine. However, since raising the basal metabolic rate and continuing the thyroid therapy, the deformity seemingly has remained fixed.

Examination in March, 1940, presented a left dorsal, right dorsolumbar curve but no further increase in deformity. The vertebrae in

epiphyseal ossifications are present about the anterior corners of the lower dorsal vertebrae. Several of the vertebrae show irregularities
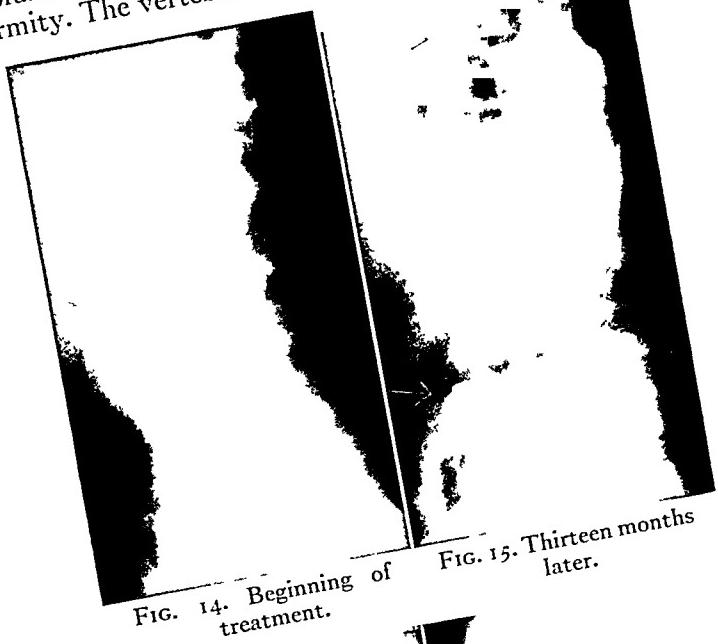
FIG. 14. Beginning of treatment.

FIG. 15. Thirteen months later.
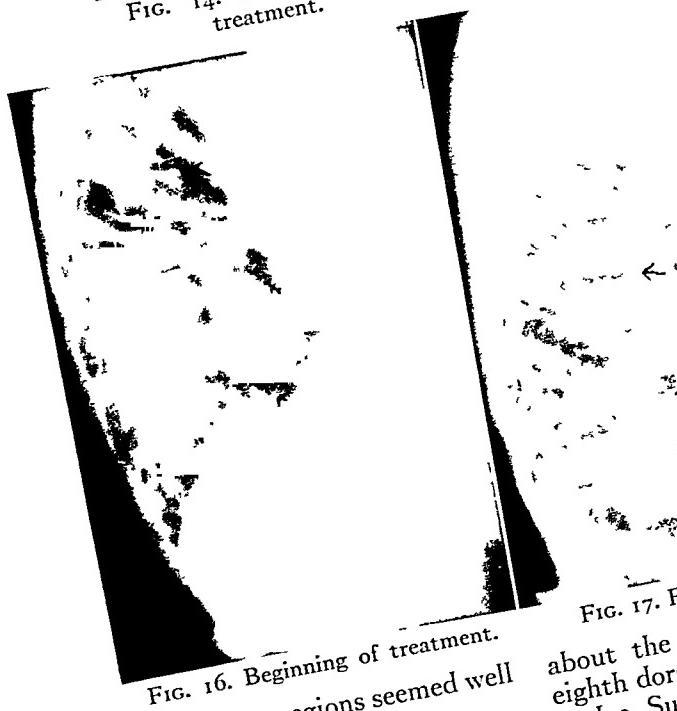
FIG. 16. Beginning of treatment.

FIG. 17. Five months later

both the dorsal and lumbar regions seemed well fixed.

CASE XXVII. B. C., age twelve years. In June, 1939, the patient complained of a prominent right hip and fatigue in the back. Examination in the upright position revealed a mild, left dorsoright lumbar curve with slight rotation. There was no muscle weakness. X-ray in June, 1939, in the prone position showed the spine to be fairly straight. "Small triangular

about the epiphyseal line. The seventh and eighth dorsal vertebrae show some tendency to wedge. Summary: the findings are those of an early epiphysitis." (Dr. G. J. Bernath.) Basal metabolic readings in June, 1939, were minus 11, minus 17 and minus 13 per cent.

The patient was placed under thyroid therapy in an average dose of 2½ to 3 gr. daily and given postural exercises for the back. At the end of two months all fatigue in the back had dis-

appeared. The moderate spinal curve was not increased.

X-ray report in July, 1940, was as follows: "Epiphyseal irregularities previously observed are still apparent. They appear to be in closer contact with the vertebral bodies at this time. There is a slight convexity of the lumbar spine." (Dr. G. J. Bernath.) X-ray report in December, 1940, showed "epiphysitis of the seventh dorsal vertebra and apparently to a slight extent of the eighth and ninth as well. No appreciable deformity is present." (Dr. E. M. Shebesta.)

Clinical examination of the spine in December, 1940, in the upright position showed the contour of the spine to be fairly straight. There was no increase in the curve. All fatigue had ceased. (Figs. 14, 15, 16 and 17.)

Discussion. It is possible for many of the so-called idiopathic scoliotics to be prevented entirely or the aggravation of an existent curvature to be ameliorated if early diagnosis is made and treatment with desiccated thyroid instituted at its recognition. Corrective orthopedic measures[14,15] must be employed when gross deformity is demonstrated ·either physically or by Roentgen ray. The changes seen in the vertebrae roentgenologically are similar to those revealed in the other so-called clinical entities. It will be most gratifying if the future proves this to be true and the incidence of this deforming condition is lessened because the other conditions do not ordinarily lead to such grave future consequences to the patient. Routine Roentgen studies should be made, therefore, in all pre-adolescents displaying postural vertebral changes. If this area were routinely included with the roentgeno-graphic study for osseous development by all clinicians interested in endocrine medicine, we believe it would be excellent prophylactic means to obviate the development of so-called idiopathic scoliosis.

SUMMARY

A consecutive group of twenty-seven cases of juvenile osteochondritis is presented. Of the twenty-seven patients two males were classified as Perthes' disease;

one male and one female as slipped upper femoral epiphyses, seven males and three females as Osgood Schlatter's disease, 5 males and 1 female as apophysitis, two males as Köhler's disease and three males and two females as epiphysitis of the spine. The age range was from five to fifteen years. All displayed definitely related symptomatology. The Roentgen diagnoses in all were unbiased as they were made by a cross-section of able roentgenologists. Every patient routinely received desiccated thyroid orally in a full, therapeutic dose. In addition, those patients displaying other signs of endocrine dysfunction, such as the late descent of testicles and delay in adolescence, were treated with the pituitary sex-like hormone. An attempt was made to correct obesity when present. All cases were ambulatory. No immobilization was necessary except for Case ix under Osgood Schlatter's disease whose knee was immobilized for only two weeks. No hospitalization was required. The expense was reduced to a minimum. Normal ossification of the epiphyses was hastened as indicated from the subsequent x-ray findings. Clinical cure was affected more rapidly.

It is our belief that the pre-accepted orthopedic methods of treatment are fundamentally incorrect and present many disadvantages. The period of immobilization is long. It can lead to restriction of joint function, muscular atrophy and loss of school and play time. The expense of hospitalization and convalescent care may rise to considerable proportions. Open operations requiring even more detailed care have not produced the desired result either etiologically or functionally because the lacking tissue differentiating factor is not supplied. While immobilization can and does relieve pain, there is no stimulation of the true etiological factor involved without thyroid therapy.

CONCLUSIONS

Chondro-epiphysitis or juvenile osteo-chondritis is a misnomer. The characteristic

epiphyseal picture is due to hypothyroidism and a consequent lack of the thyroid tissue differentiating factor. "Osteochondreal hypothyroidism" is a term suggested because we believe these changes are pathognomonic of hypothyroidism in the same manner as a definite retardation in osseous development. Basic treatment, therefore, is adequate thyroid therapy. Orthopedic procedures are secondary or adjunctive.

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FROM the pathologic point of view the bosselated type of goiter is distinctive because organic changes are expressed in terms of acinal hyperplasia and only incidentally in epithelial hyperplasia. This is the important point, not the fact that they have bosselations.

BONE DRILLING IN RESISTANT CHRONIC ULCERS

A NEW PRINCIPLE

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OF all types of ulcers, this communication will deal only with those that never produce any real, satisfactory granulations on the ulcer bed, but continue after long periods of time to have a dirty grey or yellow glistening base. The more resistant of these are those that develop excessively thick, dense peripheral scars, the removal of which carries one down to bone. They are still more resistant to repair if the lesion has edema in the periphery of the ulcer base.

There are many of these cases situated on the leg which receive conservative treatment for months or years with little, if any, benefit. They not only fail to respond to treatment, but increase in size and extent until the patient may be reduced to invalidism.

In such cases, the potentiality to heal is practically lost. The nature of the original infection may be such as to prevent, positively, the initiation of processes which lead to healing. The original specific infection may be known, as in tuberculous ulcer, or unknown.

All such cases have been heretofore very resistant to the surgeon's efforts, or to other treatment over long periods of time. While the tissues in and about the ulcer are making strenuous attempts to destroy the injurious agent, changes in the vessel wall and the connective tissues about them may become so extensive that even when the primary causative factor has been entirely removed, healing cannot take place.

In cases of this type the walls of the vessels may gradually thicken until they become incapable of supplying nutrition to the healing process. As this continues the blood vessels may become almost entirely obliterated. The unfavorable conditions brought about by the local changes in the blood vessels just enumerated may be still further complicated by other factors, especially changes in the nearby circulation, as is so frequently observed in varicose ulcers. In this instance the stasis of the general surrounding venous circulation may produce such a stagnation that healing is entirely prevented.

The relation of blood vessel walls and connective tissue varies. In the slowly developing granulations, connective tissue existing between the blood vessels may predominate and the final result may be the formation of fibrotic nodules. In this way, the ulcer becomes completely surrounded by a keloid-like border. Blood vessel walls become so thick that their lumina are practically obliterated, the ulcer becomes permanent because all nutriment is shut off and healing will not commence until a new blood supply is established which, without appropriate surgical intervention, is impossible.

These conditions are particularly well illustrated in the type of ulcers reported in this communication. In such cases, when the base of the ulcer is attached to underlying bone, it is obviously necessary to provide a new bed, if healing is to take place or skin grafting is contemplated.

In the past, the profession in general has recognized this need of establishing new circulation and to accomplish this has resorted to excision of the entire border of the ulcer or has made numerous cross incisions through the base of the ulcer and well into the surrounding soft parts, thus hoping to stimulate blood vessels to reach the base of the ulcer from surrounding tissues

The ulcer may finally heal, after such operative work and many months of

strenuous treatment, including retention of patient with elevation of limb in bed, but the resultant covering epithelium is likely to be irregular and the corium poorly developed with underlying dense fibrous tissue with thick blood vessel walls and a varying amount of cellular infiltration. Healing of this character is imperfect and if there is ever the slightest traumatism or unfavorable circulatory condition the new formation of skin is likely to break down again and the ulcer recur.

These unfavorable conditions are much more likely to result where the blood supply to the ulcerated skin is cut off by lying close upon bony tissue. Ulcers situated in regions where the bone is superficial are notoriously resistant to all types of treatment heretofore applied This is particularly true of the lower portion of the tibia where there is added the unfavorable influence of dependency.

It has been accepted by all that a disturbance in circulation is a common factor in both the causation and the persistence of ulcers. One of the most frequent examples of this is the venous congestion of the lower leg associated with varicose ulcers. This is undoubtedly the chief causative factor. There is an associated edema due to the imperfectly aerated blood in contact with blood vessel walls making this more readily penetrable to serum. The capillary circulation is influenced and lack of nutrition to the tissues follows. The ultimate result is a failure to produce healthy granulation tissue. The arterial walls may undergo hyaline degeneration which may finally result in obliterative endarteritis. The result is a granulation tissue, the blood vessels of which have thick, fibrous walls not capable of providing nutrition for a healthy healing process.

To quote Dr. Arthur E. Hertzler, "This vascular embarrassment is apt to be more pronounced in areas in which the tissue is sparse of vessels as that over the tibial crest, and for the same reason the associated infection is more apt to be intensive and add its burden to the healing process.

While the foregoing remarks apply to the ubiquitous varicose ulcers of the leg they may become the dominant factor even in the specific ulcer, particularly tuberculosis and blastomycosis after the disease has existed for a long time."

A perusal of the literature will convince any one that the surgical methods used to overcome such outstanding vascular inadequacy have not been sufficient. They have consisted, in brief, of rimming the ulcer of its indurated border with scalpel, curetting the base of the ulcer or radical incisions through the ulcer extending into its surrounding soft parts, the hope being that in time blood vessels will be stimulated to reach the desired center of the ulcer which is essential to new healthy granulations.

As has been the case too frequently, particularly in bone graft surgery, the surgeon has not paid sufficient attention to biophysiology or anatomy and has not realized that of all the blood supply coming to bone 75 per cent of it comes via the interior or the marrow of the bone, whereas only 25 per cent of it comes via the periphery or periosteum.

With these facts established, there would seem to be no chance for argument that if it is possible to tap the rich reservoir of blood under the ulcer base, in the center of the bone, this, above all others, is the objective for which to strive.

If a priori reasoning has ever come through, it has in this instance, because when the bone cortex beneath the ulcer base has been drilled sufficiently to the center of the bone, to allow blood to well up there has always been an unusually prompt appearance of healthy granulations and healing of the ulcer as demonstrated by the nineteen cases herein reported.

This has been found true in ulcers due to trauma, osteomyelitis, inadequate blood supply, due to local changes and to varicosities; phlebitis; neurogenic or trophic disturbances, deficiency in nutrition and ergot poisoning.

The surgical technic of such procedure is extremely simple. The leg is prepared as

it would be for any aseptic operation, shaved, any dead skin around the periphery and ulcer carefully removed and tincture of iodine preparation completed. At operation, an excess of tincture of iodine 3½ per cent is applied. As a last preparatory step, the ulcer is filled with 3½ per cent tincture of iodine. The indurated border of the ulcer is removed by a small, sharp scalpel. The base of the ulcer is thoroughly curetted and an additional coating of tincture of iodine is applied. With a small motor drill (⅛ inch in diameter) multiple drill holes are made through the underlying bone cortex sufficiently deep that blood wells up. This is always the criterion. The ooze soon stops from pressure of a gauze pad directly over the ulcer. The wound is then dressed with a gauze dressing saturated with paraffin 90 per cent, vaseline 10 per cent, and in order to produce complete immobilization of the part when the ulcer is near a joint and fixation is desirable, a plaster of Paris cast is applied to the limb. If the lower part of the tibia is involved, the plaster is extended from the toes to the tubercle of the tibia. The patient is then returned to bed with instructions that the operated leg be elevated to a degree of three pillows. The plaster of Paris cast is left on for a period of one week. Following this, frequent dressings are done, using either vaseline gauze according to Orr, or paraffin compound gauze.

The profuse blood supply thus brought to the ulcer has achieved healing in over two-thirds of all patients operated upon. In the remaining one-third of these cases, the treatment resulted in a granulation bed very favorable to skin grafts and because of the size of the ulcer more rapid healing has been effected by their application. Skin grafts have taken most satisfactorily upon the favorable granulation bed thus afforded. In no instance has there been deep infection from the drilling through the base of an ulcer. This, I believe, may be partly due to immersing of the drill in and the puddling of the ulcer base with tincture of iodine at the time the drill is thrust into the

bone, and partly due to the care always to drill deep enough to tap the blood supply so that it profusely wells from the drill hole precisely as one milks blood from a hole in his finger when it has been pricked.

Case No.	Duration of Ulcer before Drilling	Site of Ulcer	Cause of Ulcer	Skin Graft	Length of Time between Drilling and Healing
1	9 mos.	Metatarsal	Trauma	No	17 days
2	8 mos.	Tibia	Osteomyelitis (compound)	Yes	3 mos.
3	15 yrs.	Tibia	Osteomyelitis	Yes	5 mos.
4	1 yr.	Tibia	Osteomyelitis (comp. fracture)	No	5 mos.
5	6 yrs.	Tibia	Osteomyelitis	No	7 wks.
6	5 yrs.	Fibula	Varicose ulcer (phlebitis)	No	7 wks.
7	6 mos.	Tibia	Varicose ulcer	No	3 mos.
8	1½ yrs.	Fibula	Trauma (fracture)	No	7 wks.
9	9 mos.	Tibia	Poliomyelitis (neurogenic or trophic disturbance)	No	9 wks.
10	5 yrs.	Tibia	Trauma	No	6 wks.
11	2½ yrs.	Tibia	Osteomyelitis (compound fracture)	Yes	3 mos.
12	15 yrs.	Tibia	Ergot poisoning	Yes	2 mos.
13	3 yrs.	Tibia	Trauma (fracture)	No	4 mos.
14	1½ yrs.	Os calcis	Trauma (fracture)	No	2 mos.
15	1½ yrs.	Femur	Trauma	Yes	5 mos.
16	14 yrs.	Tibia	Osteomyelitis	No	6 wks.
17	13 yrs.	Tibia	Trauma	Yes	2 mos.
18	1 yr.	Tibia	Osteomyelitis	No	2 mos.
19	3 mos.	Tibia	Osteomyelitis	No	7 wks.

SUMMARY OF NINETEEN CASES OF RESISTANT CHRONIC ULCERS

Cause of Ulcer   No. of Cases

Trauma............................... 7
Osteomyelitis....................... 5
Osteomyelitis (following compound fracture)......................... 3
Poliomyelitis (trophic disturbance)... 1
Varicose ulcer....................... 1
Varicose ulcer (phlebitis).. 1
Ergot poisoning.... 1

Site of Ulcer   No. of Cases

Metatarsal.......................... 1
Os calsis........................... 1
Femur.............................. 1
Fibula............ 2
Tibia............. 14

Average duration of ulcer...... 4 years and 8 months
Average length of healing time.. 9½ weeks

SUMMARY

The unusually satisfactory results enumerated in detail in this communication are of particular gratification and interest

to me in that they illustrate the dependability of the principles of both physiology and biology when applied to surgical procedure.

The plan of the above treatment was arrived at by me from extensive experience in reconstructive surgery where at the operating table over a period of thirty-five years, I have repeatedly proved that the essential requirement of all reconstructive work is to make way for the provision of an adequate blood supply. I have often made the statement that new bone formation is no more likely to occur than a masonry wall without brick and mortar with which to build it, no matter how skillful the mason may be. It was my theoretical deduction that if we could bring an adequate blood supply from the center of the bone, through the cortex, directly to the base of the ulcer, by every physiological and biological principle the ulcer should promptly heal. This has been proved as definitely as it has been proved that when an adequate blood supply is brought to a bone graft, it will survive and thrive.

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DIFFUSE toxic goiter is as distinctive in the clinic as in the laboratory. It is characterized by vascular changes and a hard uniform gland. The patients show tremor, a rapid heart rate, and extreme loss in weight. In some there are eye signs; these are the true cases of Basedow's disease. The tendency is to run an acute course and to enter a remission after a period of months or years.

THE DIFFERENTIAL DIAGNOSIS OF THE "PAINFUL HIP" IN CHILDHOOD

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THIS title is chosen in order that the differential diagnosis of such a vague term as "painful hip" may be reviewed. The term is not to be regarded as a diagnosis in any way but merely as a symptom. Formerly all children with the complaint of pain in the hip were rather loosely diagnosed as "tuberculosis of the hip," but with more thorough history taking and examining acumen, aided by roentgenograms and laboratory data, other conditions have been revealed and· we should like to review some of them.

For convenience of discussion we have divided the patients with complaint of pain in the hip into three general groups: those of inflammatory origin, those of traumatic origin and the epiphyseal disturbances.

I. INFLAMMATORY

A large majority of hip affections in children are tuberculous, though tuberculosis of the bones and joints has undoubtedly decreased in the past twenty-five years. This disease was originally seen in poorly nourished children; although today when cases are seen earlier, the condition is frequently encountered in robust looking individuals. Tuberculosis of the hip joint has been classified under many names: hip joint disease, morbus coxae, quiet hip, hip disease, etc. The condition is essentially one of early childhood and the disease usually first appears in the bone near the metaphysis, while its chief manifestations are evidenced within the joint proper. In 5,000 cases of tuberculous disease, seven-eighths of the patients were less than fourteen years of age, and about 75 per cent were in the first decade of life. The disease is rare before the age of two, most of the cases occurring between the ages of three to ten years.

Very early recognition of the disease may be quite difficult. The hip joint is guarded and protected by the muscles surrounding it and to those sentinels of Nature we must look for early clinical evidence of the disease. Tuberculosis of the hip is not primarily painful. The child does not frequently complain of pain during the waking hours in the very early stages, but the so-called "night cries" are common and are often noted even though the patient makes no complaint of pain during his periods of activity. These night cries are produced by sudden movements of the joint while the patient is asleep and the muscles relaxed. A sharp spasm or contraction of muscles ensue when the inflamed or diseased joint surfaces rub together.

A careful and gentle physical examination in the early stage may disclose only muscle spasm of the adductor muscles. Next to this early muscle spasm the limp is the most important and constant sign of the disease, and it is a *constant finding*. The patient should always be stripped and placed in a good light while being examined and measured. Sometimes requesting the patient to run across the room may be the means of disclosing early an otherwise hidden limp, and a little later the characteristic clinical signs of limitation of motion in all directions, muscle atrophy and persistent flexion of the hip may be found. While the limb is initially held in slight abduction and outward rotation, the joint irritation will soon permit the strong adductor muscles to pull the hip into adduction and the limb will appear shorter than its opposite fellow. (Fig. 1.) For this reason, the lower

extremities should always be measured in the line of deformity and with the pelvis level, in order to get the true shortening.

FIG. 1. Roentgenogram showing characteristic appearance of tuberculosis of the right hip joint, showing bone destruction of both head and acetabulum. Hip has been pulled into the characteristic attitude of a flexion and adduction deformity.

In summary, therefore, a chronic, monarticular disease in early childhood, accompanied by limp, muscle spasm, muscle atrophy and limitation of motion in all directions, with or without the history of known injury, is quite suggestive of tuberculosis. In the early case the roentgenograms are of little value in determining the diagnosis, but are of inestimable value in disclosing a nontuberculous lesion. Soon after, the bone atrophy, with the blurred appearance of the joint in the roentgenogram and evidence of bone destruction, may be of great aid in confirming the physical signs of tuberculosis. The tuberculin test is a very valuable test for young children. Also, aspiration of the abscess and its injection into a guinea pig may be useful in proving the suspected diagnosis. In a suspected case of tuberculosis when other data prove negative, a biopsy from the affected joint tissue may be taken.

Bursitis. There are various bursae about the hip joint and one or more of these through injury or inflammation may become swollen. The greater trochanter region is frequently the site of bursal or osseous pathology and it may be tuberculous in origin. One should always be suspicious of tuberculosis when there is inflammation of the bursa situated in the region of the greater trochanter. The limp and pain on certain movements of the hip joint that place strain on the bursal tissue, accompanied by local swelling of the bursa, are characteristic findings in bursitis. One may see an iliopectineal or iliopsoas bursitis with accompanying muscle spasm and general limitation in joint movement, though this bursal inflammation is rarely tuberculous.

Lumbar Pott's Disease. Lumbar Pott's disease may sometimes be confused with hip joint disease, but the limitation in movement is in extension of the hip and the other motions of the joint are unimpaired. This restriction of extension combined with rigidity of the lumbar spine, with or without lumbar kyphosis, should permit one to rule out disease of the hip joint *per se.*

Inguinal Adenitis. The hip is slightly flexed but the locally enlarged and tender lymph glands are an extra-articular source of irritation. It must be remembered that with inguinal adenitis the true hip joint motion, within a small amplitude, is never restricted in all directions. It is a principle that unless the lesion is intra-articular in character, passive motion is not restricted in every direction.

Acute Poliomyelitis. There is, in the early stages of this neuromuscular condition, a sensitiveness of all the muscles with accompanying pain on movement but there is no regional muscle spasm, and the general symptoms and laboratory findings are so distinctive that ordinarily there is no difficulty whatsoever in its differential diagnosis.

Infectious Arthritis. Another type of hip deformity caused by joint inflammation is that caused by the staphylococcus, streptococcus, gonococcus, etc., all of which can be grouped under nontuber-

culous arthritis of the hip joint. In this classification are included the *epiphysitis* of childhood, as well as the infectious arthritides. A swollen, painful fluctuating joint with a history of acute onset with or without trauma and usually accompanied by marked constitutional symptoms is characteristic of the acute type of infection involving the epiphysis and indicates prompt and decisive operative treatment. Occasionally, the *mesenteric or pelvic lymph glands* may be infected and give rise to the picture of an infection of the hip joint with its pain and soft tissue swelling. *Pyelitis, appendicitis* and *perinephritic abscess* have all been confused with tuberculosis of the hip joint, but a careful physical examination combined with laboratory data are usually sufficiently conclusive to avoid confusion on this score. *Infectious arthritis* often monarticular and chronic, may arise from some focus of infection such as tonsils, sinuses, etc., and may require observation and study within the hospital to rule out completely an acid-fast infection. Roentgenograms, the sedimentation rate, the tuberculin reaction and the removal of obviously infected foci may all give indications as to whether we are dealing with a tuberculous or nontuberculous infection.

II. TRAUMATIC ORIGIN

Traumatic Synovitis. This is a condition that should be considered whenever there is a history of a recent injury to the hip in young children. This most frequently occurs in children under eight years of age, manifesting itself by pain, limp and hip flexion deformity, while all movements of the joint may present some slight restriction to motion. In this condition there is marked tenderness in the groin over the joint with usually some muscle spasm. The roentgenographic changes, however, are negative for any bone injury or disease, and this traumatic synovitis is due entirely to injury to the synovial membrane with subsequent congestion and accumulation of joint fluid. Rest in bed with or without

traction usually suffices after a week or ten days to permit a return of joint function.

Fracture of the Neck of the Femur. This fracture is not extremely rare in children, but undoubtedly many cases do go unrecognized until joint deformity has developed. The fracture is usually caused by severe direct violence to the individual, but it is very surprising how few symptoms some of these patients present. The author has had the opportunity of seeing over fifteen cases of fracture of the neck of the femur in children under ten years of age and this in children is in marked contrast to this fracture in the adult both as to the mode of onset and the disability it produces in the adult. A child may complain of nothing striking as regards the immediate effect of an injury, and may even be able to walk about with little discomfort. One case was seen three weeks after the fall. The patient complained of pain not in the hip but in the knee, and several roentgenograms had even been taken of the knee joint. On examination of this particular case the affected hip showed general restriction of motion, elevation of the trochanter above Nelaton's line with shortening and outward rotation of the limb.

The roentgenogram may show a complete fracture of the neck of the femur but more often will disclose a green-stick fracture at the cervicotrochanteric junction. This has been called a "hinge-type" fracture, and being incomplete probably accounts for the mild degree of symptoms. If not corrected, this type of fracture will give rise to a marked coxa vara deformity, though nonunion in children should not be feared. Coxa vara may be caused in a variety of ways, only one of which is a fracture of the neck of the femur. This bending or softening of the bone producing coxa vara may be of inflammatory or traumatic origin so this distortion of the neck is usually the result of a disproportion between the strength of the supportive structures and the burden placed upon it. John C. Wilson has recently reported on the slow development of an aseptic necrosis

of the head of the femur following this fracture in children, and noted this two, three and four years after the fracture and

Fig. 2. Roentgenogram of the left hip showing characteristic Legg-Perthe's disease with flattening and fragmentation of the epiphysis, accompanied by thickening of the femoral neck.

after apparently good reduction. This, therefore, is a danger to be kept in mind and warned against.

Bone Tumors. Rarely are malignant tumors of bone found involving the hip joint in children. Osteogenic sarcoma of the acetabulum occasionally is found. Pain, limp, and flexion deformity of the hip with joint limitation may develop with a cyst in the upper portion of the femur or neck. A roentgenogram will, however, easily disclose the bone changes that cause the symptoms and occasionally a fracture through the cyst may be the first evidence of its presence.

Growing Pains. This vague term is probably due to muscle strain and rarely runs a chronic course or produces much discomfort. No real difficulty in differentiating it from actual joint disease or injury should be encountered, although the symptoms may resemble those of an infectious arthritis in its early stages.

III. EPIPHYSEAL DISTURBANCES

Coxa plana, Legg-Perthes' disease, Perthes' disease, or osteochondritis deformans juvenilis, the latter term more clearly describing the pathological condition, was frequently confused with tuberculosis of the hip before the introduction of the roentgenogram. Most authors agree that this condition is an aseptic necrosis of the head of the femur caused by interference with its circulation. But others hold that it is related to disturbances of the glandular system even though there is very little proof to substantiate such a theory. Clinically, it closely resembles tuberculosis of the joint, although the prognosis is much better for ultimate joint function. It manifests itself by pain, limp, muscle spasm and atrophy, but in addition to its clinical course it presents a roentgenographic picture distinct from tuberculosis. The roentgenogram shows a characteristic flattening or roughening of the upper epiphysis of the femur as though this portion of the bone had become softened and flattened from pressure. (Fig. 2.) The femoral neck is broader and there may be a slight coxa vara present. Legg has described two forms of the disease, one presenting a so-called "capped" type of epiphysis and the other having a "mushroom" effect, and believes that the latter type offers a more favorable prognosis for the recovery of joint function. This condition is only found early in childhood, rarely before four or after ten years of age.

Epiphyseal Fracture. This slipping of the upper femoral epiphysis is a condition that may develop without any trauma or apparently a slight injury and occurs in the puberty age group between eleven to fifteen usually. There is definitely a traumatic and nontraumatic type, the latter being the most frequently seen in the fat, adolescent, Froelich type of individual. The injury causing it and the immediate disability may be so slight that the condition may be unrecognized and treated for a long time as a "bruise of the hip." The displacement of the upper femoral epiphysis is down-

ward and backward producing the signs and symptoms of limp with varying degrees of discomfort. (Fig. 3.) There is

Fig. 3. Roentgenogram showing characteristic appearance of right slipped femoral epiphysis. Epiphysis has slipped downward and backward, which is the usual position the head assumes in the deformity.

definite limitation of joint motion in internal rotation and abduction. The characteristic attitude is an adduction deformity with outward rotation of the limb and restriction of internal rotation by bone block and muscle spasm. It is very

important to diagnose and properly treat these patients early in the pre-slipping stage if a restoration of normal function is to be obtained. The most satisfactory method, we believe, is to reduce the slipping at the time by open operation on the hip and by graft, drill or pin, produce an early fusion of the capital epiphysis to the neck of the femur. This permits a restoration of joint function and prevents subsequent slipping.

CONCLUSIONS

This brief résumé in the differential diagnosis of the conditions to be found in children complaining of "pain in the hip" must necessarily be rather incomplete, but an effort has been made to stress the more commonly observed conditions in orthopedic practice.

The need for careful history taking and physical examinations cannot be overemphasized and an adherence to these basic principles will automatically eliminate certain conditions. Added to these basic principles the use of good roentgenograms and various other laboratory aids, one can early and correctly make the differential diagnosis in the child who complains of "pain in the hip."

PRIMARY BRONCHOGENIC CARCINOMA OF THE LUNG*

A CLINICAL AND ROENTGEN STUDY OF THIRTY-EIGHT CASES OVER A PERIOD OF TWELVE YEARS

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THAT controversy exists on the subject of primary lung carcinoma is well recognized. The consensus of opinion amongst most pathologists clings to the thought that lung carcinoma arises from the bronchial epithelium and that there is no epithelium lining the alveolus. The classification of lung carcinoma is varied and confusing. In the literature, one is impressed with the variations offered by pathologists and clinicians. While it is true that varied types may exist in one tumor and frequently are so found on the postmortem table, the classification is still much to be desired. Metaplasia of bronchial epithelium has been found notably in bronchiectasis, in influenza, in chronic bronchial fistulae and in bronchial mucosa subjected to trauma. What rôle these morphologic changes play in the etiology of carcinogenesis and the phenomena of chronic irritation is still unsettled. Tuttle and Womack, in a study of seventy-six cases of primary bronchiectasis in adults of cancer age were able to find only one case which developed bronchogenic carcinoma.[1] It is conceded that benign tumors of the bronchi are rare, and that by far the greater number is malignant. There is still much controversy as to whether the so-called adenoma of the trachea or bronchus is benign or malignant. Chevalier L. Jackson has reported some of these tumors as benign adenoma, while Leddy and Moersch in a recent article found eight adenomas in the trachea and main stem bronchi which they classify as malignant.[2] The same authors report twenty-five cases of a group of 125 treated by roentgen irradiation, living from twelve to 147 months, and in this survival number of twenty-five, eight were adenomas. On the other hand, best surgical opinion believes in total pneumonectomy and not lobectomy for the best possible results for radical cure. Bold advances in surgery and possible better technic in roentgen irradiation offer some ray of hope for the future to combat this deadly affliction and to overcome the present hopelessness as exists in the average case.

Some thirty years ago, the medical profession entertained a unanimity of opinion and considered carcinoma of the lung as a hopeless disease, that its treatment was of little or no avail. In the early days recognition of lung cancer during life was very rarely or not made at all and was labeled a postmortem curiosity. As one familiarizes himself with the increasing literature on the subject, he is impressed with the apparent hopelessness in a very high percentage of cases; or in other words, it is the exceptional case that escapes inevitable doom, and if it weathers the storm by operation will survive. Since Adler's publication in 1912, the literature is increasing and for the past ten years, enough material has accumulated for the clinician to secure a very comprehensive foundation for a study of this disease.[3] Because of its increasing frequency, it has ranked as a tumor of major importance, equalizing in occurrence carcinoma of the large bowel.[4] In fact, tumors of lesser consequence have received greater atten-

FIG. 1.

FIG. 2

FIG. 3.

FIG. 4.
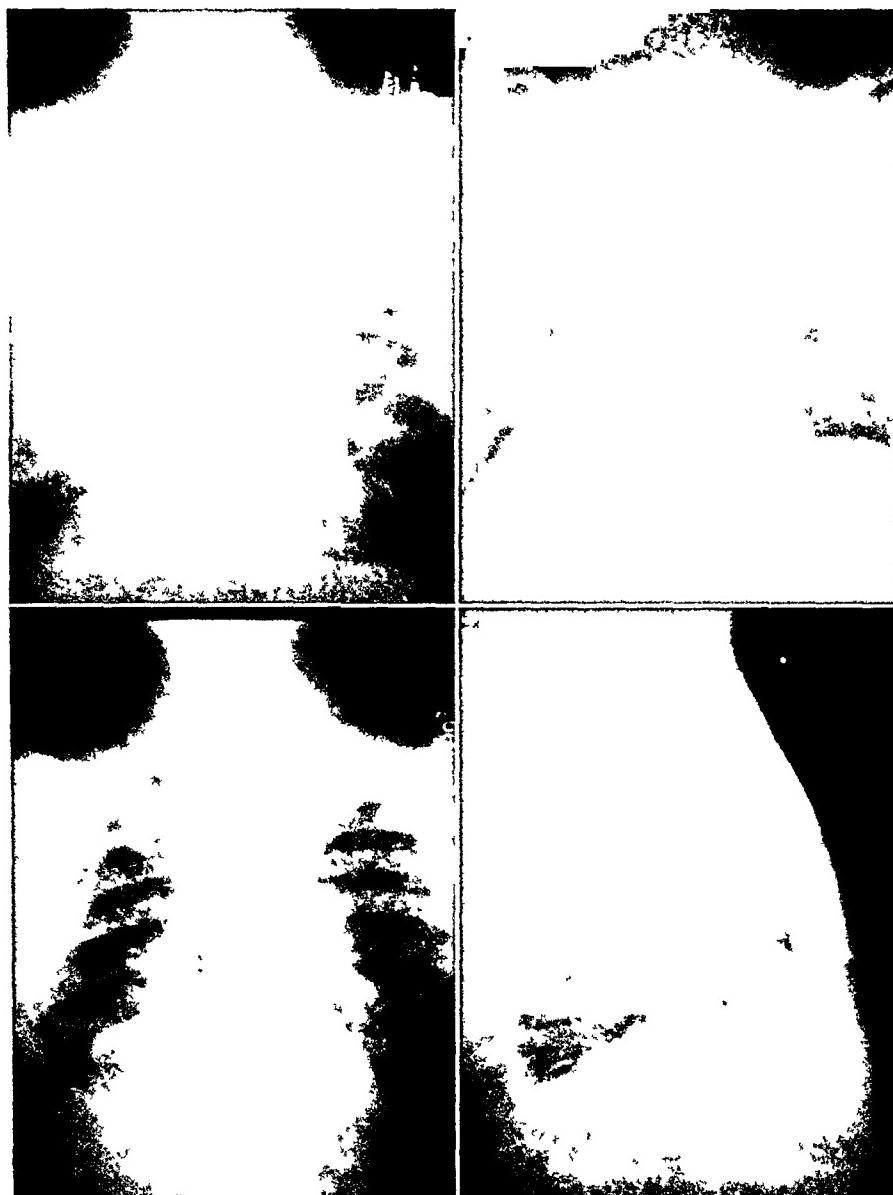
FIG. 1. Case 1. D. L., male age fifty-two. History of influenza November, 1933, followed by pneumonia on left side and recovery. January, 1934, fractured anterior sixth to eighth ribs right side followed by pleurisy. Operation, March, 1934, for encapsulated pus pocket. April, 1934, had resection of eighth anterior rib for encapsulated empyema. Pleura considerably thickened and adherent to lung. Examination of lung revealed inflammatory tissue. May, 1934, chronic empyema draining intermittently for eighteen months with bronchial fistula. January, 1936, second rib resection. Pleura incised, cavity found 5 by 2.5 cm. with smaller cavities surrounding larger one. Patient discharged with small draining fistula. X-ray taken March 19, 1934

FIG. 2. Case 1. D. L. May 18, 1936. The patient gained forty pounds since discharge. Note scarring lung at right base.

FIG. 3. Case 1. Readmission June 1, 1937. Note mass at right base. Recurrence of symptoms one month prior to admission.

FIG. 4. Case 1. Note extensive involvement of tumor mass of lung along mediastinum and posterior upper and middle lobes. Patient died September 21, 1937. Autopsy findings: (1) Extensive round cell carcinoma involving right main bronchus with extension to right middle and lower lobes. (2) Compression of mid portion of esophagus and superior and inferior vena cava by tumor mass. (3) Extensive metastases to right pulmonary hilus lymph-nodes, nodes of pancreas and spleen, duodenum, mesentery, peri-aortic and right axilla. (4) Fibrous obliteration right pleural cavity. (5) Edema of face. Lateral view taken June 1, 1937.

tion than lung carcinoma. It is said to comprise from 5 to 10 per cent of all carcinomas, and some writers even exceed these figures. In the Woodlawn Clinic and Hospital, the number of malignancies of all types from June 1, 1928, to June 1, 1940, comprise a total of 815. In this series are found thirty-eight cases of primary bronchial carcinoma, a percentage of 4.7. All suspicious and secondary tumors of the lung are excluded. In this total of thirty-eight cases, nineteen came to postmortem examination. Since some of the patients expired in other institutions, we are unable to secure sections for microscopical study in six cases.

A biopsy of a gland was obtained in three cases. Bronchoscopy was performed in two cases. One patient came to operation in another hospital and expired. One patient was operated upon three times, first for an empyema, second for a subsequent fistula and third because of a localized abscess which developed. Eighteen months later, this patient developed bronchial carcinoma. (Case I.) (Figs. 1, 2, 3 and 4.) One patient was operated upon for a spinal cord tumor which proved to be metastatic. In one case, there was aspiration of the chest in which hemorrhagic fluid was obtained and which yielded cancer cells. In nineteen cases from the history, progress and Roentgen findings, we have considered these tumors primary carcinoma of the bronchus as our intimate studies of this group, render this diagnosis a justifiable one.[5,6] In this series thirty-two patients are dead, the outcome in five are unknown and one is still living. As our knowledge of the subject increases, it is apparent that by far the greater number of cases come to the physician late, at which time therapeutic measures are of no avail, surgery is out of the question, and the disease is so far advanced that the patient and family are often unaware of the critical condition. In this series of thirty-eight cases covering a period of twelve years, only two cases could be considered early and one of these patients refused any type

of therapy. The other submitted to a pneumothorax prior to surgical removal but when the base of the lung was discovered adherent to the diaphragm, surgery had to be abandoned. (Case II.) In 300 cases that Graham studied only twenty-eight were considered early, again demonstrating that by far too many reach the physician in an advanced state. It is true that any physician familiar with the disease can recognize it by the history, progress, physical examination and a Roentgen study by a short series, in the greater number of cases.[5] Biopsy of a lymph gland, whether cervical, supra- or infra-clavicular, or axillary, or a node in the skin distant from the chest wall will sometimes yield the necessary information. Examination of the pleural fluid or sputum for carcinoma cells or bits of tissue offers another avenue for diagnosis. A puncture aspiration directly into the tumor for histologic data has lately been advocated and has developed many adherents for this type of diagnosis, a method available wherein other measures are not possible to obtain.[7] So far, there have been mentioned four avenues for a possible diagnosis: (1) tumor tissue in sputum, (2) pleural effusion, (3) gland or skin biopsy and (4) lung puncture. The fifth requires greater emphasis, since in 70 to 75 per cent of cases, a diagnosis is made from tissue obtained by bronchoscopic examination. Graham concludes that 80 per cent of tumors causing bronchial obstruction can be diagnosed by bronchoscopy.[8] In Arkin and Wagner's series of 135 cases, only thirteen were confirmed by tissue removed by bronchoscopy. In the authors' series of thirty-eight cases, only two diagnoses were made by bronchoscopy. In sixty cases studied by Hochberg and Lederer,[7] less than twenty-two had a bronchoscopic examination. (Diagnosis in twenty-two cases included bronchoscopy, biopsy of lymph-nodes or malignant cells in sputum and pleural fluid.) Jackson is of the opinion that seventy-five per cent of cases of bronchial carcinoma can be recognized by bronchoscopy; and here it may be perti-

nent to add that in some clinics and in some of the cases reported by the writers, patients presented themselves with far advanced disease. Occasionally, in the extra pulmonary cases, the lung tumor may have been small but the metastatic focus may have precipitated the symptomatology, thus tending to confuse the clinical picture.[9] Another factor enters the problem. Tumors of the major bronchi cause symptoms early, grow more slowly and are more amenable to treatment, whereas tumors at the periphery of the lung and smaller bronchi result in fewer early symptoms; in this latter group, can be classified the so-called silent tumor which by its slow

TABLE I
METASTASES—SIX CASES

	Cases
Mediastinum	
Glands right hilum	
Pancreas	
Spleen	
Appendix	
Duodenum	
Mesenteric lymph-nodes	
Peripancreatic lymph-nodes	
Periaortic lymph-nodes (3 cases)	
Right axillary lymph-nodes	
Glands—right and left hilum	
tracheobronchial	4
Liver	4
Heart	2
Muscles of thigh, kidney, dura	
Dorsal and lumbar spine	
Skull	2
Iliac bones	
Sacrum	
Ribs	
Bladder mucosa	
Skin	2
Suprarenal	2
Vaginal wall	

X-RAY METASTASES
No autopsy

Ribs	
Pelvis	
Sacrum	

progressive growth, gives rise to symptoms or distant metastasis late in the disease. Hence, when seen in this stage, the disease becomes rapidly fatal.[1] Perhaps in no disease is the dissemination of metastases so widespread. No organ is exempt and metastases to the skin and bones are relatively common occurrences. A distant metastatic focus may usher in the disease

by symptomatology that leads the clinician away from the lung and one must be on the "alert" when these foci occur, to consider bronchial carcinoma as a possibility. (Table 1.)

SYMPTOMATOLOGY

No disease offers a more varied group of symptoms than bronchial carcinoma. The symptoms are as protean as the physical findings and in a great measure depend upon the location and extent of the tumor. From the outset it can be stated that there is no group of symptoms or physical signs which can be considered pathognomonic of the disease.[7,10] It is a remarkable finding that many patients even in the advanced stage appear in good nutrition and one would never outwardly suspect malignant disease. Even in advanced disease in many instances the blood picture is little affected or unchanged. In the main, the symptoms are due to pressure and obstruction. It is perhaps essential to keep in mind two groups of symptoms: those due to pathological changes in the lung and secondly, symptoms caused by a metastatic process distant from the lung. A small primary tumor in the lung may yield no chest symptoms but symptoms may be caused by some distant metastatic focus which may complicate the clinical picture. Even a serial roentgenographic study of so short a period of three or four weeks denoting the progress and increase in size of the tumor will add to the greater probability that one is dealing with bronchogenic carcinoma. In fact, one plate taken during this period in several of the writers' cases a month apart, strongly added to the suspicion of lung carcinoma. Here the roentgenologist may be of immense aid and at least fortify the suspicion of the clinician. We wish to emphasize that the combined teamwork of the clinician, bronchoscopist and radiologist offers the ideal setup for the best interests of the patient where teamwork is a routine in the various clinics. Even independently the radiologist can be of much aid and value, for frequently the first suspicion is sug-

gested by the x-ray. One should not slight a good history which in many cases can be considered the keynote for intensive additional study to confirm the suspicion.

Cough, chest pain and weakness are the leading symptoms in the greater number of cases. To this may be added blood-stained sputum, simulating tuberculosis, and progressive increasing weakness. Loss of weight is another important factor in some cases. In our series these were the main symptoms in about one-half of our cases, cough heading the list in eighteen cases. Next, neuritis and pain from distant metastases occurred in seven cases. Two cases were ushered in by symptoms referable to the genitourinary tract, as dysuria and a mass in the vaginal wall of one year's duration; the other case presented a distant mass in the lower right quadrant of the abdomen. Six cases had a massive pleural effusion which was hemorrhagic; one case was an encapsulated effusion, the typical straw color being present that is so common in the average effusion. One case was introduced by symptoms referable to the spinal cord: severe pain down both arms and between both shoulder blades due to metastases, extradural, and masses causing necrosis of the ribs and pressure but without cord metastasis. Two cases followed chronic inflammation of the lung, and in the sequence of events that occurred later, were empyema, fistula, lung abscess, recurrence of the fistula, then a lapse of eighteen months—in which period the patient gained forty pounds and looked well—and finally the appearance of an extensive carcinoma. The original pathology was several fractured ribs which happened in a motorcycle collision. (Case 1.) (Figs. 1, 2, 3 and 4.) The other bronchial carcinoma developed after pneumonia followed by pleural effusion, resolution and a persistent hard unyielding cough covering a period of over a year. (Case ii.) (Figs. 5, 6, 7, 8, 9, 10 and 11.) One other case, a man of sixty-two came to his doctor with severe low back pain. Upon x-ray examination, an area of bone destruction was found in the ilium and sacrum. A

lung plate revealed a mass suspected as bronchogenic carcinoma which was verified later on postmortem examination. At no time in the course of this patient's illness was complaint made of symptoms referable to the chest.

Perhaps the main group of cases may classify their symptomatology as due to pressure and obstruction. While it is true that cough, dyspnea, blood-stained sputum and chest pain form a composite suspicious picture of bronchial carcinoma, an understanding of the relation of symptoms to lesions will simplify the clinical picture. Due to a growth in the bronchus, the cough is first irritating and persistent. If ulceration occurs, the sputum becomes blood tinged. If a bronchus is occluded, atelectasis develops; and if a large bronchus is involved, the heart, trachea and mediastinum are drawn to the affected side. The slow development of atelectasis is considered an important sign of bronchial carcinoma brought out very dramatically by roentgen examination. According to Chevalier Jackson, comparable to valve mechanism, there are three types of obstruction: (1) complete or stop-valve obstruction, resulting in no entrance or no exit of air into a tributary of lung and causing a slow atelectasis from the absorption of the contained air; (2) by-pass valve obstruction in which a lessened amount of air passes in and out of the lung, and (3) check-valve obstruction, in which air can pass only one way, either in or out, rapidly causing atelectasis or emphysema, as the case may be. A mobile tumor protruding and flapping in a bronchus or viscid secretion may form a ball-valve mechanism causing this latter type of obstruction. Atelectasis may also result from pressure of the growth surrounding the bronchus. Collapsed lung and tumor at times appear as one dense shadow and frequently are thus interpreted as tumor shadow alone.[6,11] Pressure on neighboring organs or structures may cause symptoms referable to the part involved. Pressure on the esophagus may cause dysphagia, on the trachea

FIG. 5.
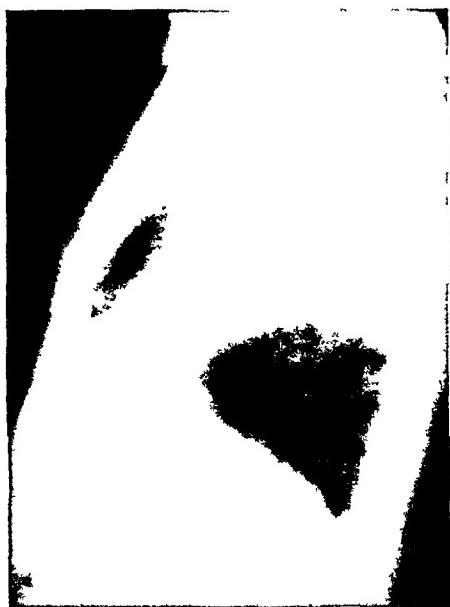
FIG. 6.

FIG. 7.

FIG. 8.
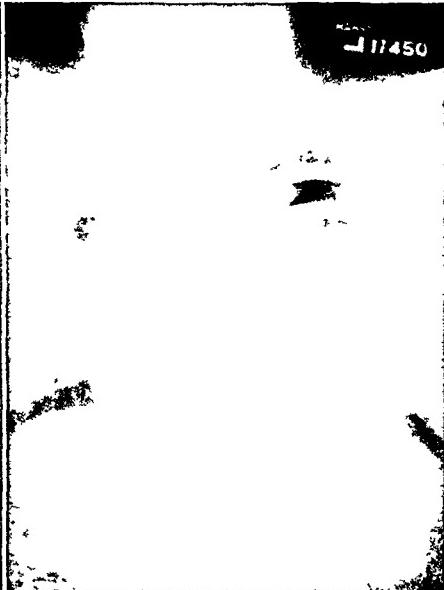
FIG. 5. Case 11. G. A. S., male age forty-five. Admission to Woodlawn Clinic April 26, 1938. History of pneumonia in spring of 1937 followed by chest pain and constant unyielding unproductive cough with slight remissions of seven months' duration. X-rays of Figures 5 and 6 were brought into clinic by patient. Note tumor mass in upper portion of left lower lobe; taken October 9, 1937; left lateral view.

FIG. 6. Case 11. Lipiodol study. Note irregular distribution in left lobe (upper and middle portions). (Print made from x-ray brought by patient.) Taken November 30, 1937.

FIG. 7. Case 11. X-ray taken day of admission to Woodlawn Clinic April 26, 1938. Note tumor mass and area of atelectasis as one shadow, left lower lobe. Greater density at left hilum and "thinning out" toward outer zone of lung. Bronchoscopy about one month later revealed squamous cell carcinoma from aspirated fluid.

FIG. 8. Case 11. November 14, 1938, seven months later. Note pneumo- thorax left chest. Base of lung found adherent to pleura. Surgery had to be abandoned.

stridor, on the recurrent laryngeal nerve, aphonia, on the cervical sympathetic, Horner's syndrome.* In one of our cases,

FIG. 9. Case 11. April 17, 1939. Note extensive growth of tumor in left lung. Patient died September, 1939.

there was transient cyanosis and edema of the chest wall which occurred on arising and gradually disappeared at noontime, due to pressure of the tumor on the great vessels and release of pressure in the morning. Dyspnea was a prominent symptom in ten of our cases. Whether this is of cardiac origin, due in some instances to the heart drawn over in atelectasis, causing interference in its action or elimination of a portion of the lung's function by solid tumor, is debatable. Chest pain occurred in eight of our cases probably due to early involvement of the pleura followed by effusion— one of the main direct causes of dyspnea. Pain is also caused by pressure on nerves or bone metastases of the thoracic cage or skeleton. Four cases had a pronounced brachial neuritis, severe pain down the entire length of one arm, from pressure of metastatic nodules. (Table 11.)

Fever is a common symptom and as a rule occurs when the tumor breaks down and disintegrates; there is invariably con-

* Horner's syndrome may consist of the following phenomena: ptosis of the upper lid, myosis, anidrosis, enopthalmos and paralysis of one or more of the vocal cords or of the diaphragm.

tamination with secondary organisms and leucocytosis may develop. With partial regression of the infection, the fever may

FIG. 10. Case 11. Squamous cell carcinoma—low power magnification. × 100. (Courtesy Dr. A. C. Strunk.)

disappear and the patient may enjoy a temporary respite and feel better. This transient improvement may lead the physician astray, thinking that he is dealing with infection of the lung and not with tumor. This cycle of events is not uncom-

TABLE II

LEADING SYMPTOMS—THIRTY-EIGHT CASES

1.	Cough	18
2.	Blood stained sputum	8
3.	Chest pain	8
4.	Dyspnea	10
5.	Loss of weight	8
6.	Weakness	13
7.	Neuritis (brachial)	4
8.	Distant metastasis-sacral pain	3
9.	Genitourinary symptoms	2
10.	Vaginal mass	1
11.	Chronic inflammation (lungs)	3
12.	Mass R. L. Q.	1

mon in some cases as there is a recurrence of symptoms, and the patient is again troubled with a renewal of symptoms and increasing weakness. (Case 11.) Tuberculosis may·simulate the tumor in this stage. If the tumor breaks down and establishes a

fistula leading to a bronchus, it may easily simulate lung abscess from which it may be very difficult to differentiate. Cough is troublesome at this time and expectoration

1. The tumor is in close proximity to the visceral pleura which it invades causing an effusion. (About 50 per cent are hemorrhagic.)
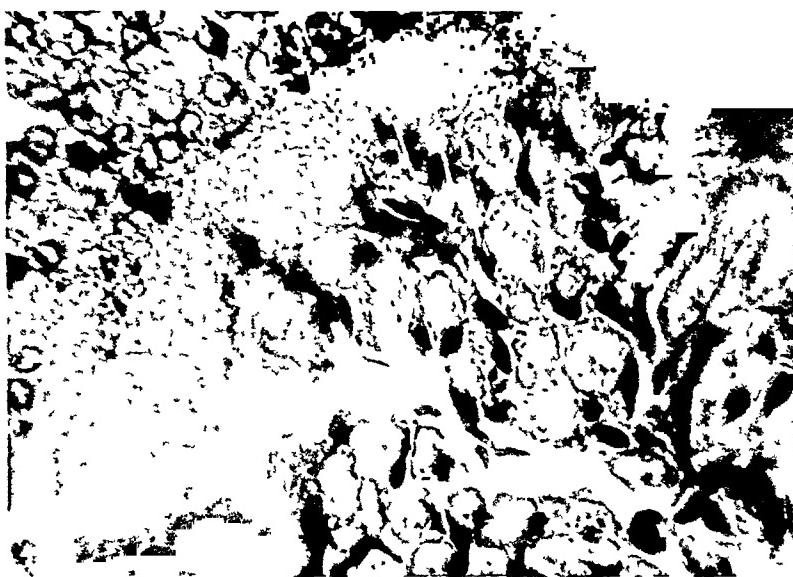
FIG. 11. Case 11. Squamous cell carcinoma. High power. Note stratified pavement arrangement of cells. Figures 10 and 11 courtesy of Dr. A. C Strunk. X 440.

is profuse. A purulent bronchitis may supervene and the breath becomes foul. The sputum will yield bits of necrotic tissue and cancer cells and a diagnosis may be established. Usually when this stage has been reached, the tumor is advanced and if the diaphragm or pleura are involved, surgery is useless.

ANATOMIC SITES IN RELATION TO SYMPTOMS

For a better understanding of bronchial carcinoma an anatomic survey of location of the tumor in relation to symptoms, affords a very comprehensive background, simplyfying the pathological and clinical aspects. We are indebted to Churchill in Christopher's Textbook of Surgery for this all-inclusive study.[12] Referring to diagram 1, the numbers represent the location of the tumor. It must be remembered that this diagram does not embrace all the aspects of bronchial carcinoma but covers the greater number of lung tumors. Differences from this survey are encountered and are to be expected from an entity which manifests so many variations:

2. The tumor is in the outer zone of lung, begins in smaller terminal bronchus or may be silent or accidentally discovered by x-ray. This type because of its fewer early symptoms is rapidly fatal. (Silent tumor.)

3. Tumor here usually results in occlusion of sizeable bronchus—tributary of lung becomes atelectatic and "drowned" by bronchial secretions. Bronchi may dilate and with bacterial invasion form lung abscess.

4. The tumor in the apex may invade adjacent structures; (so-called superior sulcus tumor of Pancoast) causing (a) paralysis of sympathetic trunk resulting in Horner's syndrome, (b) invasion of first dorsal trunk of brachial plexus giving pain referred to arm. A tumor may not be detected early. This occurred in one of our cases. The patient was treated for many months for neuritis, finally referred to clinic which on roentgen examination disclosed caries of transverse processes, lower cervical spine and upper ribs from metastases of bronchial carcinoma. (Proven by autopsy.)

5. Primary tumor or metastatic deposit may cause paralysis of recurrent laryngeal nerve or phrenic nerve on involved side.

10. Tumor invading esophagus producing ulceration or obstruction.

Many tumors as 1, 2, 3, 4, 5, 6 and 9
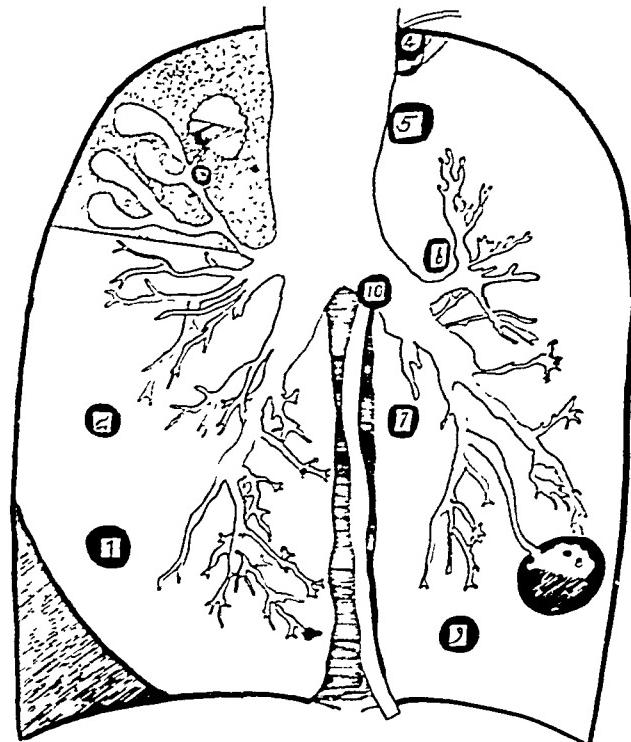
DIAGRAM 1. (From Christopher, Frederick. Text Book of Surgery, p. 931. Philadelphia, 1939. W. B. Saunders & Co.)

6. Tumor here obstructs large bronchus, causes "wheeze" to patient and sibilant râles to examiner—symptoms of foreign body, partial or complete—partial obstructive bronchus may cause obstructive emphysema (trapping of air on expiration); x-rays taken on full inspiration show density and in full expiration reveal rarefaction. Recurring attacks of pneumonitis punctuate history.

7. Tumor causes ulceration of bronchial mucosa and gives rise to hemorrhages—diagnosis of tuberculosis should be questioned in absence of negative sputum.

8. Tumors undergo central necrosis with cavitation and establishment of bronchial fistula, simulating lung abscess—may be difficult to differentiate.

9. Tumor causes irritation of central portion of diaphragm giving typical phrenic nerve distribution as first symptom.

may not be reached by bronchoscope, hence negative evidence does not exclude carcinoma.[12] (Diagram 1.)

METHOD OF SPREAD—METASTASES

Bronchial carcinoma spreads through the lungs and invades the regional lymphnodes; this may occur through (1) the blood stream, (2) the lymphatics and (3) extension through aspiration in the uninvolved or new portions of the affected lung. Dissemination of metastatic foci is extensive and widespread and involves many of the solid viscera besides the lungs, the brain, dura, skeleton, the vertebrae and skin. Nodes about the aorta, pancreas, spleen, liver and stomach are usually involved in widespread metastases. The heart, kidneys and suprarenals may likewise be involved. In one of our cases, the muscles of the thigh showed metastatic

nodules. It has been stated, that if autopsy investigation presents tumors of the lung, brain and adrenals and the histology reveals small round cells of the undifferentiated type, one need have no hesitation to diagnose primary carcinoma of the lung.[13] Statistics seem to strengthen the fact that bronchogenic carcinoma gives rise much more frequently to metastases of the brain and adrenal than cancer elsewhere in the body. Not infrequently has a brain tumor been removed only to find later that it was metastatic and the primary seat was in the lung. Now every brain tumor follows a procedure which routinely obtains a lung plate prior to surgery. (Table 1.) (Diagram 2.)

PATHOLOGY

Associated pathology may comprise the following as found in the material of thirty-eight cases. The pathological involvement of tumor to neighboring organs and structures is included.

TABLE III
ASSOCIATED PATHOLOGY
Atelectasis
Emphysema right lung (obstructive)
Thrombosis main branch pulmonary artery
Hydrothorax
Ascites
Bronchiectasis
Fibrous obliteration right pleural cavity
Edema of the face
Edema of the face and neck
Active and chronic miliary tubercles
Pneumonia—bronchopneumonia
Lung abscess

TABLE IV
PATHOLOGICAL INVOLVMENT OF TUMOR TO NEIGHBORING
ORGANS AND STRUCTURES
Compression of mid esophagus
Superior and inferior vena cava by tumor mass
Compression of tumor metastases on spinal cord

Clinical observation
Cyanosis and edema transient in one case
Occurred on arising and disappearing toward noontime

LOCATION OF TUMOR

The location of the tumor was found in the right lung in twenty-one cases and in the left lung eight times. In two cases the tumor masses were so diffuse as to make it

impossible for the pathologist to determine the site of the primary tumor. A hemorrhagic effusion occurred in six cases, four on
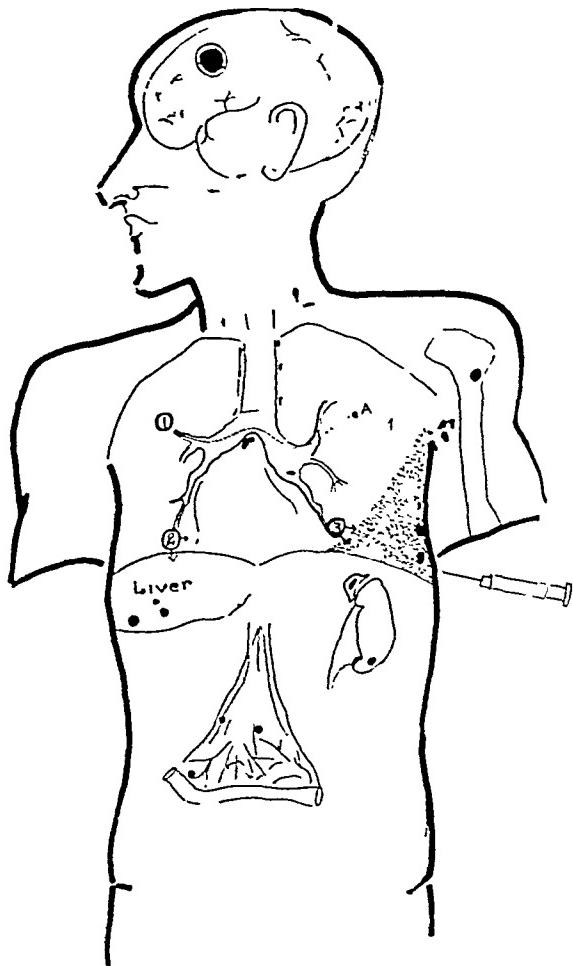
DIAGRAM 2. (From Christopher, Frederick. Text Book of Surgery, p. 930. Philadelphia, 1939. W. B. Saunders & Co.) Tumor (1) giving rise to metastases to nodes about trachea and at bifurcation of bronchi. Metastases may occur by way of lymph, blood stream and by the aerogenous route, that is conveyed to a distant part of the lung by cough, as at A, a secondary focus. Direct extension to mediastinum is a common occurrence and there is frequent invasion of the pericardium, great vessels or heart and pericardium. Tumor (1) may also serve as an example of the silent tumor, located in the outer zone of the lung which may give rise to metastases in the brain, adrenal kidney and masses in the omentum. Tumor (2) at base of right lung may extend into liver. Tumor at (3) with extension to the pleura causes a pleural effusion (usually hemorrhagic) and from which "cancer cells" may be found. Metastases from this tumor may occur to axillary glands and to skeleton as humerus.

the left side and two on the right. One encapsulated effusion was met in the right chest—straw colored fluid was present

which contained no cancer cells. In six of these cases, the effusion concealed the tumor and only after fluid was withdrawn could the nature of the tumor be determined. The roentgen features will be described in the paragraph on roentgen findings. Below is the table on location of tumors and pleural effusions.

TABLE V

LOCATION OF TUMOR—LOBES INVOLVED

THIRTY-EIGHT CASES

Right upper	2	Left upper lobe	1
Right upper lobe and left hilum	5	Left lower lobe	6
		Left hilum	1
Right middle lobe	4		
Right hilum	3		
Right lower lobe–left lower lobe	1		
Right middle and right lower lobe	1		
Right lower lobe	4		
Right lung	1		
Diffuse	2		

Hemorrhagic Pleural Effusion

Left	4
Right	2
Encapsulated effusion right (straw colored)	1

SEX AND AGE

In the series of thirty-eight cases, there were twenty-eight males and ten females, a ratio of about 3 males to 1 female. Twenty-one cases occurred in the fifth and sixth decades which seemed to bear out the statistics in the literature.

INCIDENCE AS TO SEX AND AGE

Decade	Male	Female	Total
Fourth	6	3	9
Fifth	10	1	11
Sixth	11	4	15
Seventh	1	2	3
	28	10	38

ETIOLOGY

From a study of the material, one is not able to place any definite facts or suggestions as to the probable etiology of bronchogenic carcinoma. In the twenty-eight males, most of them were smokers as well as eight of the females. Arkin and Wagner found 98 per cent of their patients were chronic smokers. This may be a contributing factor, but in addition, exhaust gases from automobiles, tar on roads, and chronic inflammation are others. Any chronic inflammatory process of the lung can be considered a contributing factor. Inhalation of various dusts and radio-active substances has also been found as contributing factors. The histologic changes of bronchial epithelium brought out by Tuttle and Womack, when this tissue has been subjected to trauma and chronic irritation, are of much interest. Whether hyperplastic and metaplastic changes are precursory steps in carcinogenesis open up an attractive field for investigation, but suffice it to say that these morphologic changes do occur. These same authors in a study of seventy-six cases of bronchiectasis were only able to find two cases of bronchogenic carcinoma. What rôle syphilis or tuberculosis may play in the etiology of cancer is not known, but as a whole, these diseases do occur in association with carcinoma. Jaffe in a study of one hundred cases found 20 per cent of carcinoma associated with anatomic or serologic evidence of syphilis which is rather high compared to the statistics of other authors. This high incidence of syphilis in lung carcinoma may be due to the high percentage of colored patients in Cook County Clinic. Active tuberculosis is mentioned as an infrequent finding associated with lung carcinoma.[14]

Grossly three forms are recognized by pathologists: (1) The hilus form which Boyd believes constitutes 90 per cent of all tumors; (2) the miliary form which resembles metastasis from a distant focus and also resembles miliary tuberculosis, and (3) the diffuse form which may involve a part or an entire lobe or a whole lung and closely resembles pneumonic consolidation.

MICROSCOPIC PATHOLOGY

There is much confusion among pathologists as to the classification of bron-

chogenic carcinoma. Recent authors have demonstrated that the so-called round cell, oat and spindle cell carcinomas unquestionably arise from the bronchial epithelium. The majority of pathologists concede that most of the tumors arising in the bronchus are malignant and that benign tumors are extremely rare. Prevailing opinion seems to be that carcinoma arises from the bronchial epithelium since there is no epithelium lining the alveolus. Most pathologists offer this classification: (1) squamous, (2) adeno-carcinoma and (3) small cell type, oat or fusiform. Many variations from these three have been recorded but by far the greater number fall into these three groups.

The following data reveal the microscopic findings from three sources.

JAFFE[11] 100 CASES (POSTMORTEM)
31 round cell (undifferentiated)
28 squamous
24 adenocarcinoma
88 oat cell carcinoma
4 carcinoma simplex
2 scirrhus carcinoma
3 goblet cell carcinoma

KOLETSKY[15] 100 CASES (POSTMORTEM)
35 small cell carcinoma
40 squamous
22 adenocarcinoma
3 carcinoma simplex

WOODLAWN CLINIC 19 CASES (POSTMORTEM)
7 squamous carcinoma
1 round cell carcinoma
2 alveolar carcinoma
1 mixed cell carcinoma
6 no microscopic obtainable
1 adenocarcinoma
1 medullary carcinoma

Many authors agree that the grading of bronchogenic carcinoma on histologic grounds is of little practical value. These types of tumors do not differ in their gross appearance neither are there any appreciable differences as to the duration of life or extent of metastases.[1,4] Graham classifies them into two large groups: 65 per cent squamous and 35 per cent mixed.[8] He believes that the mixed type in a young person is potentially malignant, and for the best prognosis favors early removal of the lung. Arkin and Wagner believe that the

squamous type is less malignant than other forms and offers the best prognosis for early surgical removal, although six of their eighteen cases, had brain metastases. The squamous type presented metastases in the liver, kidney and adrenals, one third as less frequent as in the other forms.[5] Because of its comparatively slow growth, the squamous cell type offers the best prognosis for early surgical removal. Many authors in the recent literature hold a similar opinion.[6,8,15]

ROENTGEN FINDINGS

As a primary requisite, it must be emphasized that there are no roentgenologic findings characteristic or pathognomic of bronchial carcinoma. What then are the criteria which may guide the roentgenologist or clinician? The writers have previously stated that the teamwork of the clinician, bronchoscopist and roentgenologist best serve the patient for a proper diagnosis. In order of first importance may be considered a unilateral shadow at the hilum which is not due to increased vascular markings and whose border may be well circumscribed or fades into the parenchyma as a "feathery" cloudy density. This shadow is considered one of the earliest signs of bronchial hilus carcinoma and may be due in some measure to invasion in and surrounding the bronchus. Next in importance is atelectasis due to partial or complete bronchial obstruction, whether caused by invasion of the lumen or by peribronchial pressure of the invading tumor. The atelectatic area may involve part or the whole lobe or the entire lung, depending primarily on the degree of stenosis, the location and extent of the site of obstruction. The resulting collapse of the involved lung area, displaces the heart, trachea and mediastinum to the affected side. The imprisoned air, as previously described, undergoes slow absorption, and there ensues local edema. If secondary infection occurs, multiple small abscess cavities develop, resembling localized bronchiectasis. Usually, the atelectatic lung is

roughly triangular in shape and if small may possess a well defined dense border. As the tumor grows, the bronchial wall is
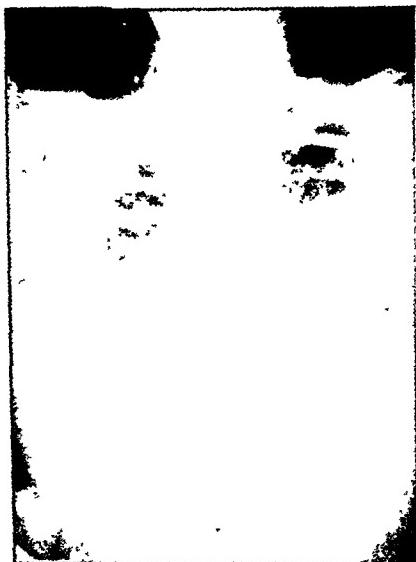
FIG. 12. Case III. R. B. P., male age forty-two. Nervousness and irritability for one year. The patient was admitted to Woodlawn Hospital October 11, 1937. He had pain in the left chest of a neuralgic type, rather severe one week prior to admission. Slight cough was present. Fluid in left pleural cavity masks tumor. Note heart in normal position. Aspirated fluid, hemorrhagic.

perforated and invades the parenchyma. Eventually, large areas of infiltration cause consolidation of part or the entire lobe or lung and are visualized as dense massive shadows. The periphereal type of tumor occurring in the smaller terminal bronchi and distant from the hilum (at times, the so-called silent tumor) may or may not be associated with atelectasis. By its slow growth it is apt to cause fewer early symptoms and usually is first encountered in an advanced stage. If part necrosis of the tumor does occur, small cavities develop and with bacterial invasion, bronchiectasis follows; coalition of the cavities gives rise to the formation of lung abscess. With the tumor in an advanced stage, it is frequently impossible to decide whether the type is peripheral or central. Secondary processes render it more difficult to differentiate basic pathological changes. The

table of associated pathology represents the findings in our series of thirty-eight cases.

A few remarks in relation to pleural effusion should not be omitted. Jaffe in one hundred cases encountered forty-three with pleural effusion. The character of the exudate was as follows: serous, fourteen cases; hemorrhagic, thirteen cases; suppurative, twelve cases; fibrinous, four cases. In addition, there were twenty-six cases of partial and twenty-three cases of complete obliteration of the pleural cavity. Only eight cases revealed no pleural changes.[14] Our series of thirty-eight cases demonstrated six hemorrhagic pleural and one encapsulated (straw colored) effusions. The tumor may be concealed by the effusion and it is our policy to radiograph the chest as soon as possible after removal of the fluid on account of rapid reaccumulation. In several of our cases the fluid did not cause displacement of the heart even though large effusions of 1500 cc. and over were obtained. (Case III, Fig. 12.) This finding has puzzled us and so far we have been able to offer no satisfactory explanation. However, it has made us consider lung malignancy as a possibility when this phenomenon occurs. We also believe injection of air (at least 200 cc.) after aspiration is a good procedure to follow as it makes the tumor outline more visible. (Case III, Fig. 12.)

CONCLUSIONS

Primary cancer of the lung still remains a problem both as to early diagnosis and treatment. By far too many cases are first seen when the tumor is well advanced. The solution of the problem is for early diagnosis and is similar in scope to the entire cancer situation; namely, education of the public, and an earnest attempt by the physician to recognize the condition in its earliest stages. The writers are impressed reviewing the literature with the apparent hopelessness of the disease, but one can become "cancer conscious" especially in an adult over forty who presents leading

symptoms such as chronic cough and bronchial obstruction, chest pain, dyspnea, and so forth, in short, pulmonary symptoms which may make carcinoma probable. One must not overlook similar symptomatology in those under forty that lung cancer may be present. And again, the symptoms and signs of distant metastases should be considered with the possibility that the primary tumor may exist in the lung. As clinicians, we are interested in the controversies of pathologists and research workers concerning morphological changes of tissues, primarily bronchial epithelium, and until this aspect is settled perhaps pathologists can come to some better understanding of histological classification. One cannot emphasize too strongly the greater need for early bronchoscopic examination and measures to be taken for biopsy of a lymph-node, early examination for cancer tissue or cells in pleural fluid, sputum and from lung puncture. Lastly, x-ray examination should be complete, thorough and repeated, especially if a suspicion exists. The therapeutic outlook is by no means hopeless.

Chest surgeons today believe that lobectomy is inadequate and that the best results are obtained by a total pneumonectomy. Up to 1939, eighty-six pneumonectomies are recorded in the literature, resulting in thirty-one recoveries and fifty-five deaths, a mortality rate of 63.9 per cent.[10] Some statistics of the later cases up to 1939 are as follows: Graham, a total of four cases, three deaths and one recovery, one patient living six years; Freelander, a total of five cases, with four deaths; one patient living three years; Overholt, a total of eleven cases with three deaths; 2 patients living five years, one patient living four years and five living one year; Edwards, five cases, one death and four recoveries; Churchill, five cases, three recoveries, two deaths, one patient living over five years and two living over three years; Ochsner, DeBakey report nine cases, three recoveries and six deaths, one patient living three years and 2 living one year.[16]

Head of Chicago reports one pneumonectomy patient living one year and one lobectomy patient living two years.[16] Leddy and Moersch report a series of 125 patients treated with roentgen therapy and another group of 125 untreated.[2] All were proved cases of bronchogenic carcinoma. Of the 125 patients treated by roentgen therapy, twenty-five are living over a period from twelve to 146 months. Of the twenty-five living patients, eight cases of adenocarcinoma were found as follows: one in the trachea, one in the left upper lobe and two each in the right main bronchus, the right middle lobe and the right lower lobe, respectively. These tumors are the so-called adenomas of the bronchi which has caused considerable controversy as to their malignancy. Jackson in a recent lecture described these tumors of the bronchi which he considered as benign adenoma.[17] Recent bold advances in surgery and possibly greater improvement in roentgen irradiation offer for the future a brighter outlook in the cure and alleviation of this serious disease.

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To the operating surgeon the situation of the thyroid gland is of prime interest. The attachment is so intimate that when the larynx rises in the act of deglutition the thyroid gland follows. Yet there is a layer of connective tissue lying between the thyroid gland and the larynx sufficient to make it possible to dissect the former from the latter without the least danger of injury to either.

PATHOLOGY OF APPENDICEAL STUMP
WITH SUGGESTIONS FOR PROPHYLAXIS

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ALTHOUGH the prime object of this article is to report specific cases of pathology of the stump and to suggest prophylactic measures against such occurrence, I should like to enumerate the historical and controversial facts connected with the management of the appendiceal stump.

Historical. The early operations consisted in mere ligation of the stump. Krönlein, in 1886, advocated simple ligation. Treeves, in 1888, sutured the stump which he covered with three Lembert sutures. Senn, in 1889, suggested inversion of the stump. Dawbarn, in 1895, invaginated the stump without ligation. Fowler made a peritoneal cuff for the stump. Lillienthal, in 1903, recommended simple ligation. Seelig, in 1904, likewise recommended simple ligation. Alton Ochsner, in 1939, suggested inversion without ligation, insuring against hemorrhage by a hemostatic purse-string suture.

METHODS IN THE MANAGEMENT OF APPENDICEAL STUMP

A. Simple Ligation without Inversion: Arguments in Its Favor. It was found that simple ligation is all that is necessary in most cases. In an analysis of 1,000 cases by J. F. Baldwin[1] this method was effective. This procedure brings about good hemostasis. There is no infection, if the stump is properly cauterized (Seelig). Maloney[2] did not find either ileus or adhesions among 3,500 cases in which simple ligation was practiced.

Arguments against This Practice. If the ligature should slip, there is the possibility of leakage with its consequences. Edebohls found in several instances infection originating in the ligated stump. Ligation resulted in fecal fistula in several instances. Some observed postoperative adhesions, intestinal obstruction, blowout and sinus formation.

B. Ligation of Stump Plus Inversion: Arguments in Its Favor. A large number of clinical recoveries indicate that the method is safe. It is the method *en vogue* with the majority of American surgeons.

Arguments against It. Since the cecal wall is only $\frac{1}{16}$ inch thick, it is possible for the needle to penetrate the wall and reach the lumen, thus infecting the suture. The suture may interfere with the blood supply. Lexer observed cases of intestinal obstruction following this technic. Kohler found postoperative adhesions at the site of inversion. Abscess in the wall of cecum was found by Bogetti and Robertson, pathologist of the Mayo Clinic. Riedel noticed ulceration in the wall of cecum. Some cases resulted in fecal fistula. Many cases exhibited areas of inflammation of the cecal wall. Maloney found foreign body tumor in the inversion area. Cecal diverticuli were found by Bunto (three cases) and by J. Shelton Horsley. Ortner, taking x-rays after appendectomy found that the barium appeared as a ring around the stump. Chas. H. Mayo,[3] in 1934, attempted to summarize the whole situation and gave four reasons against this practice: (1) Robertson, pathologist of the Mayo Clinic, found at postmortem examinations pus pockets in the area of the inverted stump as late as twenty-one days postoperatively; (2) purse-string suture was invariably infected; (3) this procedure lengthens convalescence, and (4) he found no occasion to regret.

C. Inversion of Stump without Ligation: Arguments in Its Favor. No dead space is

formed. There is chance for drainage of infected material in lumen of the bowel. Bürkle-de-le-Camp, reporting on 3,200

through the courtesy of Dr. F. M. Sylvester, Oak Park, Illinois.

The patient was operated upon two years
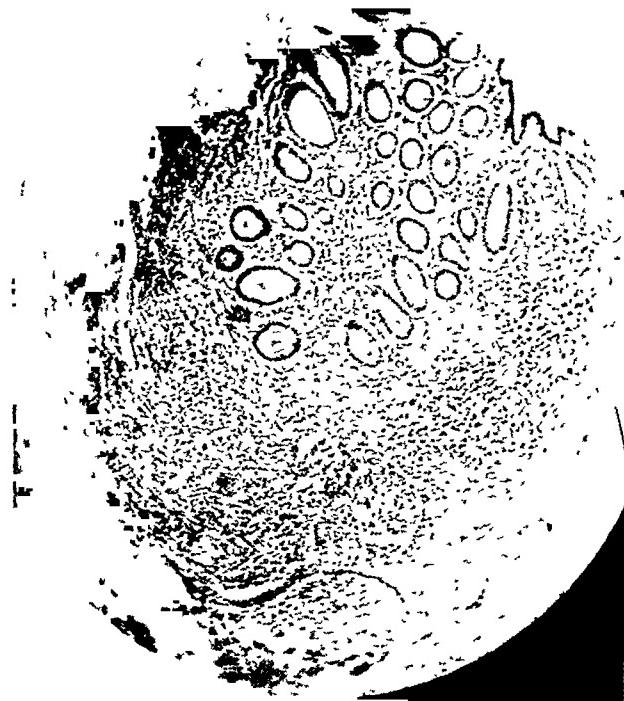
FIG. 1. Shows the average histologic picture of appendiceal stump from cadavers which retains most of the histologic features of an appendix and is easily recognizable as such.

cases from Lexer's clinic found no post-operative necrosis, abscess, fecal fistula or hemorrhage. Alton Ochsner[4] inverts the stump without ligation, but insures hemostasis by inserting a loop suture around the meso-appendix attachment to the colon, and by a purse-string suture in the cecum which includes any branch of the appendiceal artery. There is no chance for infection because the stump is inverted in the lumen instead of the cecal wall.

Arguments against Its Use. The stump may open before inversion is completed. The purse-string suture may become contaminated. There is the possibility of hemorrhage. Fowler[5] observed an artery running longitudinally within the wall of the appendix, which is not tied in this procedure.

CASE REPORTS

CASE I. *Peritonitis from Rupture of Old, Infected Stump.* I am enabled to report this case

before for acute appendicitis. She made an uneventful recovery but exhibited after the operation a symptom complex which was suspected to be due to a duodenal ulcer for which she received medical treatment. When seen by Dr. Sylvester, two years after the original appendectomy, she had a stormy attack of severe abdominal pain referred chiefly to McBurney's zone. There was localized tenderness and temperature of 101°F. Because of the previous history of duodenal ulcer and in the absence of the appendix, Dr. Sylvester thought that the clinical picture may be explained on the basis of ruptured duodenal ulcer. The doctor made an S-shaped incision extending upward toward the ribs and downward toward McBurney's zone. To the great surprise of the surgeon, he found that the patient had a diffuse peritonitis due to infection and rupture of an old appendiceal stump. The patient was adequately drained, but four days later she died.

Final Diagnosis: Peritonitis due to infection and rupture of an old appendiceal stump.

CASE II. *Large Mucocele in Cecal Wall, Originating in Old Appendiceal Stump.* This

male patient. age fifty, had an appendectomy performed ten years before entering the hospital for the present operation. He was free from

tion and stated that the mass was a mucocele which originated in an old appendiceal stump. Pathological examination revealed the fol-

Fig. 2. Shows the continuity of the lumen of the appendix with that of the cecum.

abdominal symptoms until three years ago when he noticed a swelling of the right groin, which was diagnosed inguinal hernia. From time to time he had pains in the groin referred to the abdomen but never had an acute abdominal complex. He entered the Mt. Sinai Hospital, Chicago, for the repair of an inguinal hernia.

Examination was essentially negative, except for some mental incoherence and evidence of premature senility with intellectual confusion. Physical examination revealed a white male with no particular physical defects or handicaps, except a large right inguinal hernia. The size of the mass did not conform to the physical characteristics of either direct or indirect inguinal hernia. The mass was bulky, had an irregular contour, and was reducible by a sort of invagination of the lower abdominal segment. The inguinal ring was somewhat tender to pressure, the tenderness extending in the right iliac fossa where a mass was felt which could not be definitely diagnosed.

The operation revealed a right inguinal hernia of the sliding type, the outer aspect of the cecum being a part of the parietal peritoneum. Externally to the cecum, but closely connected with it, there was a mass, soft in consistency and shaped like an adult testicle. This mass could not be separated from the cecum and was finally removed. One of the assistants who was not sufficiently familiar with the case thought that we were dealing with an undescended testicle, a part of a sliding hernia.

The pathologic report elucidated the situa-

lowing: The specimen consists of a hernial sac measuring about 100 by 90 mm. and up to 4 mm. in thickness. The inner surface is grayish-pink and shows trabeculations. The outer surface shows a moderate amount of connective tissue.

The specimen is a tensely filled sac measuring approximately 40 by 30 by 30 mm., the contents of which are a viscid, jelly-like fluid with some fat tissue suspended in it. In the wall there is present a node measuring 15 mm. in its largest diameter, which has on secretion surface a grayish-white appearance. In another area there is present a small node which has a brown and hemorrhagic appearance. The inner surface of the sac is hemorrhagic with yellowish-brown deposits.

The microscopic report was as follows: Sections show in areas a dense connective tissue mixed with a pale blue, loose and edematous material containing fibroblasts and a few star-shaped cells in addition to many capillaries and blood vessels which are distended with blood. Old blood pigment and infiltrations with lymphocytes, plasma cells, neutrophilic and eosinophilic leucocytes are present. Large and small calcified areas are present, of nondescript morphology, some of them surrounded by multinucleated foreign body giant cells. In areas the surface is lined with a tall, columnar epithelium with basal nuclei and a very abundant clear cytoplasm. In one area embedded in a very edematous connective tissue, which resembles somewhat the above described mucinous tissue, is a lumen surrounded by

glandular structures and lined by a tall columnar epithelium with lymph follicles and germinal centers. It has the appearance of the appendix.

Diagnosis: Hernial sac with a chronically inflamed appendiceal mucocele. Chronic foreign body type inflammation.

CASE III. *Granuloma in Cecal Wall at Site of Old Appendiceal Stump.* (Referred by Dr. Estelle Anis, Chicago.) The patient was a housewife, age twenty-two. She had an appendectomy performed two years previously and made an uneventful recovery. Ever since she complained of pain in the lower half of the abdomen with some vague urinary symptoms. The pain was intense enough to consult a physician and seek relief at various times during the past two years.

Physical examination was practically negative except for definite tenderness in McBurney's zone, especially on deep pressure. Although the diagnosis was not definite, the patient was persistent in her complaint and was anxious to undergo an exploratory operation. At the time of the operation the findings were as follows: A knob, the size of a large cherry, was present in the cecum at the site of the inversion of the appendiceal stump in the wall of the cecum. Several omental flaps were pulling on the peritoneum, one of them lifting up the bladder. There was considerable mesenteric adenitis. There was also an imperfect closure of the fascia. The omental flaps were separated from the peritoneum and bladder. The knob in the cecum was removed, which required the removal of a segment of the cecum. This was done by applying a light stomach clamp upon the cecum and the defect was repaired with two rows of suture. The peritoneum was closed by making an ectropium, according to the suggestions of J. B. Murphy, in order to prevent adhesions.

The laboratory findings were as follows: There was a fibrous nodule which bulges on to a pink-tan mucosal surface. The latter is speckled with hemorrhage in its lymph follicles.

In paraffin sections stained with hematoxylin and eosin the tissue in the appendiceal stump is typical of appendix and provided with a lining in which there are large mucous glands and large lymph follicles with distinct germinal centers. About one-third of the muscle layers are replaced by fat and contain lymphocytic infiltration sparsely. The appendix-like material

covers everything and rises as a short nubbin above the surrounding cecal tissue. Sections in two planes reveal the same changes.

Diagnosis: Appendix stump.

HISTOLOGIC SECTIONS OF APPENDICEAL STUMP FROM CADAVERS

It occurred to me that if the stump retained the histologic pattern of the average appendix, showing the presence of follicles, mucosal pattern and, above all, intact blood vessels, the stump was still viable. In other words, the individual was the possessor of a short appendiceal stump potentially capable of pathology. With this end in view, I have collected a series of appendiceal stumps from fresh cadavers who had appendectomies performed at various times in the past. This was made possible by the help and courtesy of Dr. Alexander Ragins of the Pathologic Department of the Cook County Hospital, Chicago. His summary account of the histologic findings of these slides are as follows:

Practically all slides show an early recognizable appendiceal stump represented by mucosal pattern, lymphoid follicles, blood vessels. The muscular coat most often is replaced by scar tissue. The proximal portion of the stump is seen merging into the cecal mucosa. In some instances the stump measures 1 to 2 cm. in length, while in others in which the appendiceal stump was very short, scar tissue replaced the short stump and in some instances exerts a pull upon the cecum, causing a slight, small, diverticulum. In short, most cadavers still possessed an appendiceal stump, which had all the earmarks of an appendix.

The following illustrations are typical of many appendiceal stumps in cadavers, and Dr. A. Ragins has selected two typical patterns.

SUGGESTIONS OF TECHNIC

Whatever technical method may be used in appendectomy, it does not seem entirely logical to leave behind a stump which is a part of a pathologic organ. On the face of

it, it would seem more logical and thorough to remove the entire appendix. Dr. Joseph Price, of Philadelphia, once stated that he who leaves behind one-eighth of an inch of appendiceal stump has performed only seven-eighths of the operation. There is no doubt that an ideal state of affairs would call for a total and complete appendectomy. The fact that the surgical profession obtained clinical recoveries even though they left behind a stump, explains the lack of desire or incentive for changing what seems to be a satisfactory procedure.

John B. Deaver,[6] evidently mindful of this inadequate surgery, removed the appendix by extirpating a small segment of the cecum which he held between the thumb and index finger, after which the defect was repaired by two rows of sutures. This method was thorough enough, but could hardly be recommended to the "occasional operator," as the cecum could slip between the surgeon's fingers, thus soiling the field. He eventually abandoned this procedure and returned to the prevailing methods of dealing with the stump.

Zeller[7] and Haggard[8] removed the appendix by cutting it flush with the cecum and subsequently repaired the defect in the bowel.

If one should have an inclination in performing a total appendectomy, the following suggestions are made:

The base of the appendix does not terminate abruptly at the cecum but often seems to run intramurally, thus deceiving the surgeon. I have followed the plan of dividing the peritoneal films which creep up upon the base of the appendix, and to

my great surprise I have frequently found that I could obtain another half, three-quarters or even an inch of the appendix which I had not suspected. This procedure definitely brings out more of the appendix. If one wishes to go beyond this, one could apply a short, curved, rubber-covered intestinal clamp upon the cecum, thus removing the entire appendix and a small segment of the cecal wall. The protruding tissue beyond the clamp may be cut away with curved scissors, the raw surface touched with iodine or cautery and finally the defect in the bowel closed according to the principles of intestinal surgery. If such procedure is used, it is advisable for the operating surgeon to change his gloves at this point and ask the assistants to wash their gloves thoroughly in running sterile water.

I fully appreciate that this procedure transforms a comparatively simple technic into a more difficult and dangerous one, especially in the hands of the less experienced. Yet, I cannot help believe that the diseased appendix might be removed *in toto*, thus avoiding all the criticisms and occasional mishaps connected with leaving an appendiceal stump.

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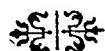
THE EMERGENCY CONTROL OF POSTPARTUM HEMORRHAGE*

EXPERIENCE WITH A SUPPLEMENTARY TECHNIC

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THIS communication is concerned only with bleeding from the relaxed uterus immediately after delivery and omits any consideration of bleeding from cervical or vaginal tears. Since postpartum hemorrhage is still one of the principal causes of death after childbirth, any effective method of preventing or controlling it is decidedly in order. Modern obstetrics sometimes seems complicated. It is, therefore, necessary in this report to show that the procedure advocated is safe and useful.

Following separation of the placenta, control of bleeding from the uterus is effected almost entirely by its contraction, thus producing a literal strangulation of the interspersed sinuses. Coagulation of the blood is of little primary importance as a patient can become exsanguinated too quickly.

The advent of pain-relieving agents during labor, often followed by anesthesia in which the anesthetic may be of a relaxing type (ether), has brought about a situation which requires new methods of treatment. This is especially true when dealing with a thinned-out, overdistended uterus, the condition being aggravated by drugs and anesthetics. Even following delivery in which exhaustion is not a factor, uterine tone may be so impaired that, while it is sufficient to separate the placenta partially or completely, it is not sufficient to clamp down the uterus immediately in the vise-like manner so desirable. A moderate delay in contracting may permit a large amount of blood to escape.

Previously the time honored method of waiting twenty minutes for the separation and expulsion of the placenta was good treatment and gave satisfactory results. Over twenty years ago one of the authors (R. A. W.), in a study involving over 2,000 deliveries in which no anesthetics were used, found only one instance of severe postpartum hemorrhage. Conversely, it is our opinion that this conservative method of treatment is often inadequate in modern obstetrical practice.

The late Dr. Ralph Pomeroy taught that each mother has in her blood under normal conditions ecbolic substances sufficient in amount to produce the desired uterine contraction. He also showed that it is not difficult to neutralize these substances by fatigue, drugs and anesthetics, and claimed that the matter was largely quantitative. For example, uterine contractions may be weakened by morphine and ether, or a contracting uterus may be transformed into a soft, jelly-like bag by deep anesthesia previous to version. As far as possible this relaxation of the uterus should be prevented.

We give as a prophylactic measure an oxytoxic substance immediately after the delivery of the baby in order to anticipate and prevent any relaxation and at the same time to hasten the separation and expulsion of the placenta. In this institution for more than fifteen years we have routinely administered pituitrin intramuscularly immediately after the birth of the baby. In only a few cases has the placenta been retained,

and on no occasion was difficulty experienced in expressing it under a mild degree of anesthesia. We believe this mild complication is unduly feared and should not be allowed to counterbalance the beneficial effects of the early administration of this drug. These effects are so striking that no member of our staff would wish to return to the method of giving an oxytoxic only after the delivery of the placenta.

It is not our intention to discuss the relative value of uterine and vaginal packs. The former may be dangerous, the latter deceptive, and neither will control bleeding without firm uterine contraction.

To produce this contraction additional intramuscular injections of pituitrin or ergot preparations are effective in most cases when used in conjunction with uterine massage and elevation of the organ well out of the pelvis. It should be borne in mind, however, that if bleeding is profuse many minutes may elapse between intramuscular injection and uterine response. If bleeding is serious, a very rapid contraction can be obtained by the intravenous injection of pituitary or ergot preparations. In certain institutions this method is used routinely, but it is not yet certain that it is free from danger, nor is it always available due to lack of personnel or failure of technic.

Many operators inject pituitrin directly into the uterine wall at cesarean section. We have found this method satisfactory. The resulting contraction is rapid and marked and only a few minims need be used to prevent bleeding. At the point of injection there is immediate blanching which spreads in a few seconds in all directions and the contraction may even make suturing of the uterine incision difficult by reason of its hardening and thickening. This clearly shows that excessive bleeding can be controlled if the necessary drugs are brought to the uterus in sufficient concentration and without loss of time. Certain English writers advocate the injection of pituitrin into the uterus through the abdominal wall. This appears radical and yet is claimed to be relatively safe.

TECHNIC

As there are some desperate situations in which the direct injection of an oxytoxic

Fig. 1. Technic of injection. Cervix is pulled down to introitus and needle enters lower uterine segment through anterior cervical wall.

drug into the uterus may be desirable, we have tested a method for introducing it in a somewhat different manner. Our technic is as follows: The cervix is either lightly grasped by the anterior lip with a smooth sponge forceps and pulled down, or it is pushed down by fundal pressure into the lower part of the vagina until it is well visualized. Using a small needle (22 or 24 gauge), 1 cc. of pituitrin is injected through the anterior wall of the cervix directly into the lower uterine segment. We have found that the injection should not be made into the edematous anterior cervical lip but must be made high in the anterior fornix through the cervix directly into the uterine wall to the depth of 2 to 3 cm.

To prove the effectiveness of such a procedure we now present a series of cases in which this method alone was used. One hundred unselected ward patients were tested. A delivery table was equipped with a Pastore blood-measuring apparatus which permitted an accurate mensuration of the blood loss during all stages of the delivery but with a trap so arranged to permit the spill of liquor amnii. No oxytoxic was given until after the delivery of the placenta when the transcervical injection of 1 cc. of pituitrin was made. The

blood loss was measured from the time of the perineal incision until the time of the injection. An assistant's hand was placed on the fundus to determine the time when the firm uterine contraction was established. The blood loss from the time of the injection until the time the patient left the table was also recorded, the sum during all stages being the total measured loss. After the patient was placed in bed, an intramuscular injection of an ergot preparation was given for its prolonged effect.

Of the one hundred patients comprising this series, forty-three were primipara, fifty-seven multipara, the ages varying from seventeen to forty-three years with an average age of 26.4 years. The average duration of labor was 14.9 hours for the former, 9.7 hours for the latter. There are an insufficient number of cases to correlate the duration of labor with the incidence of postpartum hemorrhage. The method of delivery is shown in Table 1.

TABLE 1

Method of Delivery	No. of Cases	Percentage
Spontaneous	62	62
Prophylactic forceps	24	24
Low forceps	6	6
Mid forceps	2	2
Breech .	6	6

There is no direct relationship between this and the occurrence of bleeding since nine of the fourteen cases of hemorrhage followed spontaneous deliveries. We know that hard instrumental deliveries, versions, extractions, etc., all produce postpartum hemorrhage not only because of frequent vaginal and cervical lacerations, but also because these procedures follow hard labors in tired, often deeply anesthetized patients who may have had an inordinate amount of analgesia. Incidentally, in thirty-three of our cases we were able to measure the blood loss from the episiotomies alone by plugging the upper vagina with gauze. It is

of interest to note that the average blood loss was over 100 cc. and approached 500 cc. occasionally. The slow but steady flow of blood from perineal vessels cannot be ignored.

TABLE II

Total number of episiotomies	67
Number of second degree lacerations	7
Number of first degree lacerations	10
Measured blood loss from 33 episiotomies	25 to 500 cc., average 105 cc.

For the purposes of this study the routine use of pituitrin immediately after the birth of the baby was omitted. We anticipated and found an increase not only in the incidence but particularly in the severity of postpartum hemorrhages. Before installing a blood-measuring apparatus, estimated immediate postpartum hemorrhages of 500 cc. or more appeared in 4 to 6 per cent of our deliveries. The actual mensuration of the blood loss (Table III) proved how easy it is to underestimate this.

TABLE III

	Oxytocic after Second Stage	Oxytocic after Third Stage
Total number of cases	100	100
Average blood loss	259 cc.	310 6 cc.

Total Number of Hemorrhages	No.	Per Cent	No.	Per Cent
500 cc. or over	8	or 8	14	or 14
600 cc. or over	3	or 3	11	or 11
1,000 cc. or over	0	or 0	4	or 4
Average duration of third stage.	1 to 22 min. 6 5 min.		1 to 33 min. 10 0 min.	

Using the prophylactic injection of pituitrin and measuring the blood loss, postpartum hemorrhage occurred in 8 per cent of one hundred patients, three of whom bled 600 cc. or more. By omitting this prophylactic oxytoxic, we have proved our clinical impression, finding the incidence of postpartum hemorrhage of 500 cc.

now reaching 14 per cent, four patients losing as much as 1,000 cc. of blood. Notice that not only was the incidence of hemorrhage nearly doubled but large hemorrhages predominated. The duration of the third stage varied from one to twenty-two minutes with an average of 6.5 minutes when pituitrin was administered early. Without it the third stage lasted from one to thirty-three minutes with an average duration of 10.0 minutes. These figures undoubtedly prove the value of the use of pituitrin as soon as the baby is born.

A general anesthetic was used for 97 per cent of the deliveries and this point is worth noting; the average duration of the anesthetic in fourteen patients who had hemorrhages was 35.3 minutes while for a total of ninety-seven patients it was only 25.7 minutes.

Having produced relaxed uteri which bled profusely, we were now dependent upon only one method for controlling them, namely, the direct, vaginal, transcervical injection of pituitrin into the lower uterine segment after the placenta had been delivered. Our results are tabulated in Table IV.

TABLE IV
Average blood loss before injection......... 237 cc.
Average blood loss after injection.......... 95.3 cc.

The average blood loss before injection was 237 cc. After injection the average blood loss was only 95.3 cc. This means that uteri relaxed by analgesia, anesthesia and often fatigue can be injected directly with a drug, resulting in an average blood loss of less than 100 cc. following the injection. The speed and effectiveness of this method of administration is shown by the figures in Table V.

TABLE V
Interval between injection and firm
    uterine contraction............ 46 cases timed 10
                                    to 660 seconds
Average.................... 84 seconds

In forty-six cases that were timed it was possible for an assistant to palpate the uterine contraction after injection and record the time necessary for its produc-

tion. The average interval between injection and a firm uterine contraction was eighty-four seconds. Thus we have a method which, properly executed, will produce a firm contraction of the uterus within a minute and one third even in tired, relaxed organs.

The method is not completely perfect. The response was excellent in ninety-three instances and bleeding after injection was minimal. (Table VI.) Seven of the fourteen

TABLE VI
SUMMARY OF FOURTEEN CASES OF HEMORRHAGES

Case No.	Blood Loss before Injection: cc.	Blood Loss after Injection: cc.	Total Loss: cc.	Interval before Contraction
1. 21511	500	300	800	10 sec.
2. 21426	440 plus 40 from vagina	20	500	300 sec.
3. 16856B	900 plus 300 from vagina	0	1200	60 sec.
4. 16915B	1100	0	1100	60 sec.
5. 21549	350 plus 75 from vagina	100	525	60 sec.
6. 21585	500	200	700	60 sec.
7. 15513	600	0	600	10 sec.
8. 21547	250 before first 200 before second	50	500	Good; relaxed in 7 min., repeated
9. 21518	300 before first 200 before second	200	700	Boggy until repeated
10. 21463	300 before first 200 before second	700	1200	Poor
11. 21563	500	250	750	480 sec
12. 15823	550 plus 250 from vagina	250	1000	600 sec.
13. 9581C	300	300	600	60 sec.
14. 19773A	250	500 (mostly from vagina)	750	12 sec

cases in which hemorrhage occurred responded immediately. Note that two of these patients bled 900 cc. and 1,100 cc., respectively, before injection; formidable hemorrhages were immediately controlled by this method, there being no blood loss following injection. Of the remaining seven in which the response was poor, the injection was repeated in three with immediate response in two of these. This leaves only five cases in which the response was poor immediately or following second injection and only two of these bled as much as 500 cc. after injection. Of the entire one hundred patients there were only twelve who

bled 200 cc. or more after injection or injections. We believe that these failures are technical failures and this impression is strengthened in those instances in which the uterus failing to respond to the first, probably incorrect injection, reacted so rapidly to the second. Six different members of the house staff used this method and few technical errors show how quickly it can be mastered. That there was not more actual blood loss following these injections is surprising for a uterus relaxed and distended with blood will necessarily expell 200 to 300 cc. when it contracts.

TABLE VII

Total number of cases	100
Gross morbidity	4 or 4%
Corrected morbidity	3 or 3%
Maternal mortality	0
Fetal mortality...	0

We believe that this method is safe. Of the one hundred patients in whom it was used only four had a morbid* puerperal course, one of these being caused by mastitis. This gives a gross morbidity rate of 4 per cent and a corrected morbidity of 3 per cent which compares favorably with the hospital morbidity rate of 2.5 per cent. There were no fetal or maternal deaths. (Table VII.)

In no instance was the patient morbid for more than three days. It does not appear

* Standard of morbidity—single rise to 100.4°F. in two consecutive twenty-four-hour periods excluding the first.

that this method increased the danger to the patient from infection. When it was first used, we were fearful of puncturing large vessels. If such has been the case, we have not been able to detect it nor find the slightest untoward effect.

CONCLUSIONS

1. Certain fundamental considerations of the cause and treatment of postpartum hemorrhage are discussed.

2. Two series of cases are compared showing that the prophylactic injection of pituitrin after the second stage of labor decreases the incidence of postpartum hemorrhage by nearly 50 per cent, almost eliminates the very severe hemorrhages and decreases the duration of the third stage.

3. An infrequently used method of controlling postpartum hemorrhage has been tested, i.e., direct transcervical injection of pituitrin into the lower uterine segment.

4. In one hundred patients the average blood loss following such injection was 95 cc.

5. Firm uterine contractions were produced after an average of eighty-four seconds in forty-six cases that were timed.

6. This method seems safe, no ill effects having been found, and there has been no increase in the morbidity rate.

THE TREATMENT OF PELVIC INFECTION
BY IONTOPHORESIS OF A CHOLINE
COMPOUND

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THE operative treatment of chronic pelvic inflammatory disease is unsatisfactory. Half-way measures selected because of the desire to conserve essential function are inadequate and usually result in the need for further surgery. It therefore is generally admitted that nonoperative or conservative treatment should be given an extensive trial before the patient is subjected to operative intervention and when this fails, the operation should be a radical one. For this reason, any therapy which may improve the results of conservative treatment should be of value. Conservative treatment, as we understand it, may be discussed under four headings: rest, measures to increase general resistance to infection, chemotherapy and, finally, the induction of pelvic hyperemia.

The value of rest in aiding the subsidence of infection is well recognized. This includes not only rest from physical exertion, but rest from sexual stimulation and intercourse. Unfortunately, the economic status of many patients prevents the discontinuance of their usual occupations.

As for the value of measures designed to raise the resistance of the patient to infection, there appears to be no question but that repeated small blood transfusions are beneficial. This is especially true if the inflammatory condition is complicated by anemia. Such treatment, however, requires hospitalization, is costly, and even when followed faithfully cannot be expected to bring about complete cure. In this connection also may be considered the use of foreign protein therapy which at one time was a favored method of treatment but has since been largely discarded.

The advent of chemotherapy was hailed as the treatment likely to answer the problem but unfortunately the results have been disappointing. In the treatment of the initial infection and acute exacerbations of chronic infections chemotherapy is of great value, especially when the gonococcus is the etiologic agent. In the subacute and chronic forms in which inflammatory tubo-ovarian masses or cellulitic exudate can be palpated treatment by sulfanilamide is generally disappointing. Our experience (1) in a group of seventy-four hospitalized patients with severe chronic and subacute infection has shown that the use of sulfanilamide in such cases is followed by very little improvement over the results obtained by prolonged rest in bed. We believe, however, that chemotherapy is of value in (a) primary gonococcal infections, (b) if the gonococus can be demonstrated in acute exacerbation of a chronic infection, and (c) if the Streptococcus hemolyticus is the etiologic agent. More recently we have been using sulfathiazole, a sulfonamide with a wider range of action against the various pathogenic bacteria causing pelvic infection. It is yet too early to evaluate our results.

The induction of pelvic hyperemia in the treatment of the chronic and subacute forms of pelvic infection remains one of our valued methods for treating these disorders. The hot douche, Elliot treatment and diathermy are examples of methods long since used to produce pelvic hyperemia. In pelvic iontophoresis of a choline compound, however, the most intense degrees and prolonged durations of pelvic hyperemia can be brought about. When

pelvic hyperemia is indicated, pelvic ionto-phoresis promises to be the method of choice.

The use of iontophoresis of medicaments in the treatment of localized infections is not new, and there is definite laboratory evidence to indicate that when mecholyl chloride, a choline compound, is used, the absorption of the drug will produce active hyperemia. Jacoby[2,3] has been principally responsible for awakening interest in the use of this therapy for pelvic infection. We have used pelvic iontophoresis of a choline compound in the treatment of the severe forms of subacute and chronic pelvic infection and have already reported our results.[4,5] While this method of treatment is in no sense a cure-all, it has a definite place in the treatment of pelvic infection. After briefly describing the technic of treatment, a summary of our results and the types of pelvic infection responding best to the therapy will be presented. (Fig. 1.)

TECHNIC

The technic is quite simple and may be used as an office procedure for patients with pelvic inflammatory disease. The following equipment is necessary:

1. An apparatus capable of delivering a direct current of 15 to 20 milliamperes.

2. A vaginal electrode consisting of a metal rod surrounded by insulating material and terminating at one end in a small mobile crosspiece of metal.

3. Twenty cc. of ½ or 1 per cent mecholyl chloride (acetyl-beta-methyl-choline chloride) and a quantity of gauze sufficient to be soaked to about saturation.

4. An abdominal galvanic pad 6 by 8 inches.

5. A bivalve vaginal speculum and uterine dressing forceps.

The procedure is as follows: Before beginning treatment the abdominal pad is placed in warm tap water. Occasionally, difficulty in raising the milliamperage is due to insufficient soaking of the pad. With the patient in the lithotomy position, the speculum is introduced, the cervix exposed and all secretion is wiped away so that the drug may come into intimate contact with the vaginal mucosa. The gauze soaked with the solution of the drug is placed around the vaginal end of the electrode and introduced into the vault of the vagina. The small crosspiece of the electrode should be at right angles to the main bar and preferably in the posterior vaginal fornix. The gauze covered electrode is then held firmly against the fornices and the speculum withdrawn. The vaginal electrode is always attached to the positive pole and the current is increased very slowly to 15 or 20 milliamperes. The patient generally experiences a slight local sensation of shock if the current is increased too quickly. The abdominal pad is held firmly against the skin by a binder or sand bags. A sensation of pricking, burning or sticking due to failure of the pad to make sufficient contact may be eliminated by having the patient make pressure with her hands over the pad. Treatment lasts about twenty minutes, and at its conclusion the current should be decreased gradually otherwise the patient may experience a slight local shocking.

Local effects are rare but such systemic reactions as an increase in the pulse rate, flushing, sweating, lacrimation and salivation are common and result from absorption of the drug. It is desirable to have some systemic effect in order to be certain that absorption of sufficiently active solution of the drug is taking place. Treatments should be given every other day for a period of two to four weeks depending on the response to the therapy.

The following groups of hospitalized patients were studied: (1) fifty-eight patients with severe pelvic infection, thirty-seven having tubo-ovarian and twenty-one cellulitic infections; (2) thirty-nine patients with myomas and clinical evidence of pelvic inflammatory disease, or tumor degeneration, or both.

Our estimation of the value of pelvic iontophoresis is based upon unusually rapid improvement in the clinical and

laboratory findings. Subsidence of fever, pain and abdominal tenderness, diminution in the size of inflammatory masses, and

disease, degeneration of myomas, or both. As a result of frequent operation in the latter group, material for pathologic study
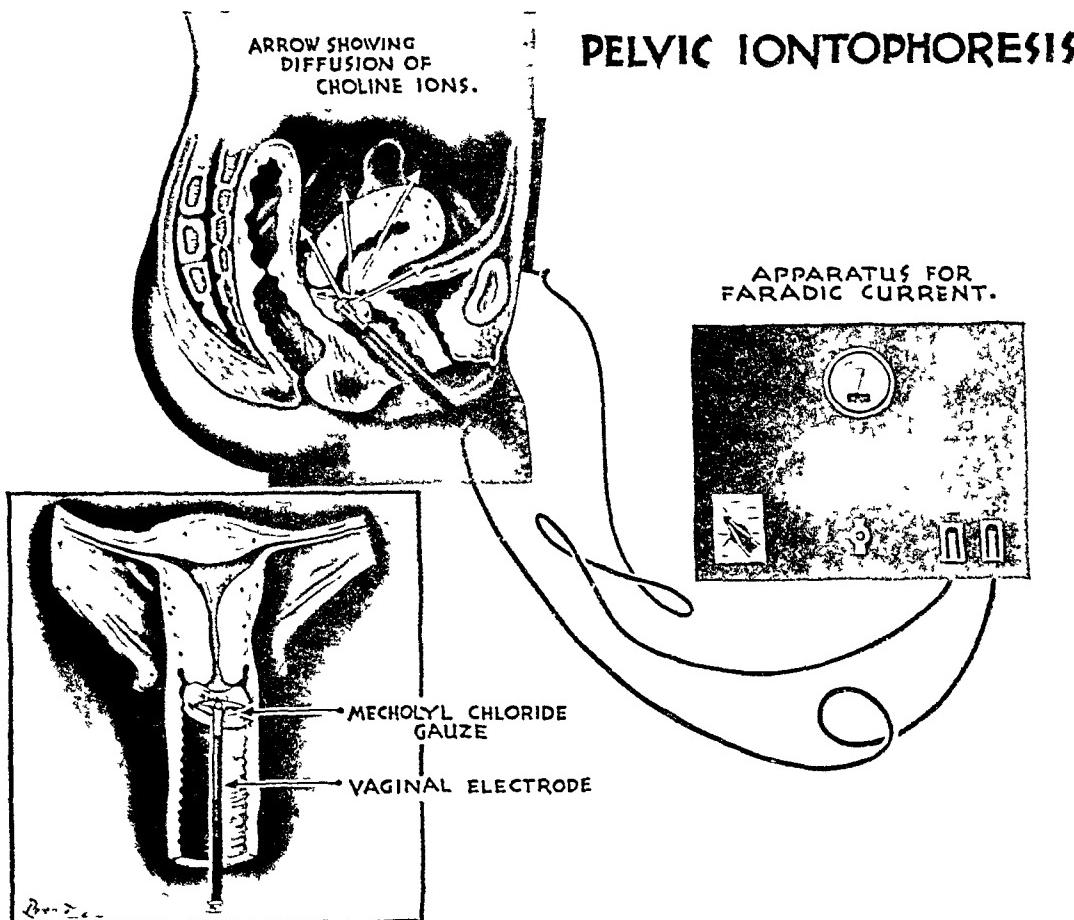
FIG. 1. Diagrammatic illustration of relationships of apparatus and pelvic organs in iontophoresis. (From Gordon, C. A. and Rosenthal, A H. Studies in pelvic iontophoresis. Am. J. Obst. & Gynec., 41: 237, 1941.)

more favorable leucocyte counts and sedimentation rates have been the criteria of improvement. It is clear, of course, that subacute or chronic pelvic inflammatory disease, whether associated with myomas of the uterus or not, tends to improve on bed rest alone. Observation of more than 500 cases of pelvic infection a year in our wards at the Kings County and Long Island College Hospitals has made us reasonably familiar with what to expect from bed rest, transfusion and supportive therapy.

SUMMARY OF RESULTS

1. Pelvic iontophoresis of a choline compound was given to fifty-eight hospitalized patients with severe pelvic infection and thirty-nine patients with myomas of the uterus associated with pelvic inflammatory

was available in the great majority of cases, thus affording an excellent opportunity for determining the type of pathological condition treated and the effects produced.

2. The results of therapy in tubo-ovarian infections while often good were not sufficiently good to warrant routine use of this method of treatment. It would seem that one cannot hope for resolution of old inflammatory tubo-ovarian masses since fibrosis and multilocular cysts are a prominent part of the pathological condition. It may, however, be given a trial in persistent tubo-ovarian infections which do not respond to other methods of treatment as well as in those patients in whom operative treatment is not indicated.

3. The best response to the therapy was noted in cases of massive cellulitic infection

of recent origin which failed to yield to ordinary treatment. Pelvic iontophoresis is recommended in particular for this type of infection.

4. The preoperative preparation of myomas associated with pelvic inflammatory disease may often be shortened with this method and the operative risk decreased.

5. In cases of myomas complicated by degeneration, iontophoresis had either no effect, or more commonly accelerated the degenerative processes.

6. In cases of myomas in which the differential diagnosis between accompanying infection or degeneration is difficult, the method may aid. It will prevent undue preoperative delay in awaiting for satisfactory laboratory data in the case of degen-eration and, on the other hand, will help to avoid the dangers incurred in operating in the presence of pelvic infection.

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THE important point in the study of the colloid in normal thyroid glands is that it shows tinctorial changes identical with those seen in cardiotoxic goiters. This suggests that the thyroid need not attain goitrous dimensions in order to affect the heart. There is no other organ of the body which shows such early and extensive degenerative changes as does the thyroid gland.

SURGICAL TREATMENT OF AXILLARY HIDROSADENITIS SUPPURATIVA*

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HIDROSADENITIS suppurativa is a chronic inflammatory disease characterized by the formation of ab-

FIG. 1a. Inflammatory reaction around apocrine sweat glands; b, ulceration of the epidermis.
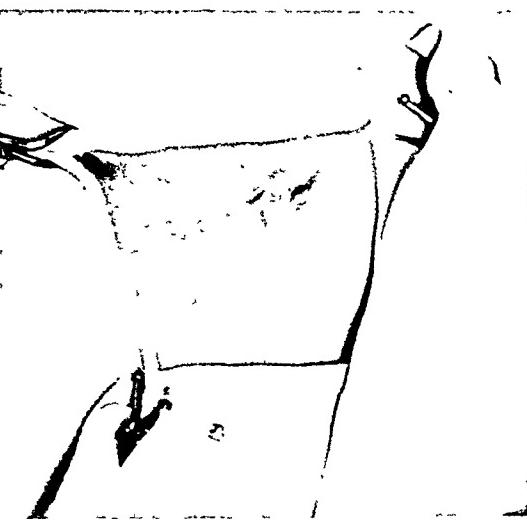
FIG. 2. Hidrosadenitis suppurativa of the right axilla; recurrent type of short duration.

FIG. 3. Extent of excision which includes all the axillary hair-bearing area.

scesses, sinuses and ulcerations in selected regions such as the axillary, mammary, inguinal, genital and perianal. The disease may be of general involvement with extensive ulceration and undermining of the skin and subcutaneous tissue or limited to one region, commonly the axillae.

The disease has also been described under such titles as abscess or furunculosis of the axillae, the buttocks or the anus, pyoderma, nonspecific granuloma and fistulous disease of the buttocks.

The occurrence of the disease in particular regions is attributed to the presence of a peculiar type of sweat gland. Verneuil,[3,4] who brought the condition to attention in a series of reports between 1854 and 1865,

recognized the association of the abscesses with the sweat glands. These peculiar sweat glands, known as apocrine glands, arise

FIG. 4. Removal of skin graft from the thigh which is chosen as the donor, a Paget dermatome being employed.

from the hair follicles instead of from the epidermis and become active at puberty. Their biologic significance was pointed out

FIG. 5. The graft sutured in position Multiple perforations of the graft are visible.

by Schiefferdecker in 1922. The apocrine glands are thought to be remnants of the scent glands, which in some animals are associated with sexual attraction. The apocrine glands do not secrete sweat but

function by rupture of the cell membrane with extrusion of the cellular protoplasm into ducts which open either directly into

FIG. 6. Postoperative type of dressing employing sea sponge for compression.

the hair follicle or on the epidermis adjacent to the follicle. It is the plugging of these ducts and subsequent infection that lead to formation of abscesses.

The onset of the disease is usually insidious, with a feeling of discomfort, pruritus and burning. With progression of the process, pain develops and a nodule becomes palpable. Frequently this is followed by the appearance of new nodules. Because of the deep-seated infection suppuration is rare and involution may take place. In the more favorable cases the condition will respond to early conservative treatment; however, the process may persist and extend into the deep layers of the subcutaneous tissue with the formation of extensive sinus tracts and of characteristic cord-like elevated bands. This cord-like structure is characteristic of the infection and results from the coalescence of multiple nodules. In the later stages of the disease, in those cases in which the condition has not responded to conservative treatment or in neglected cases, there occur inversion and undermining of the cutaneous margin with destruction and fibrosis of the sub-

cutaneous fat and connective tissue, leaving epithelial bands to connect the sinuses. Extensive ulceration and loss of all the

reported the axillae alone were involved. In thirteen of the twenty-two cases the onset was in the axilla.
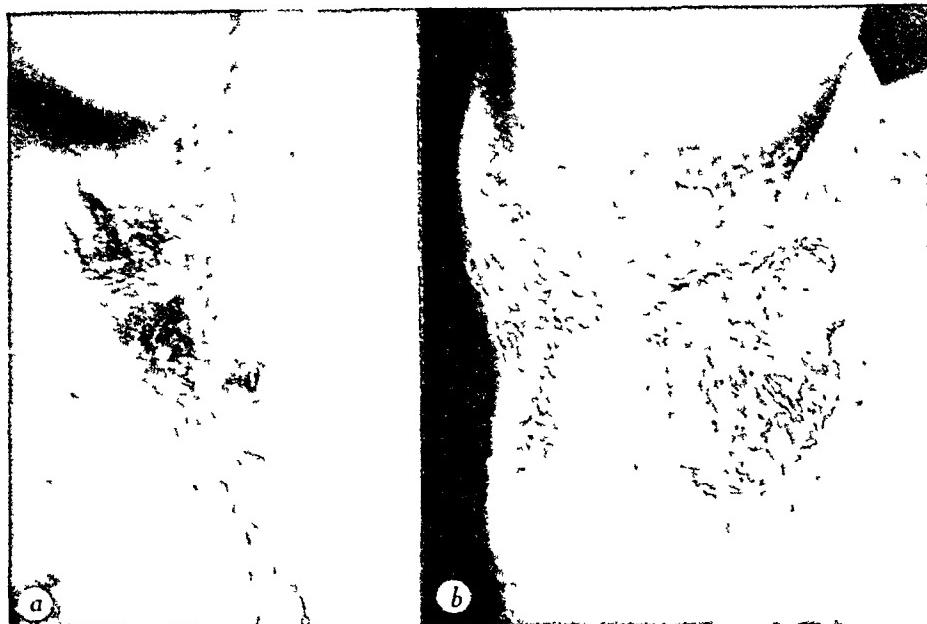
Fig. 7a. Hidrosadenitis suppurativa of the right axilla, an early recurrent type with sinus and scarring present; b, appearance of the graft with a complete take two weeks postoperatively.
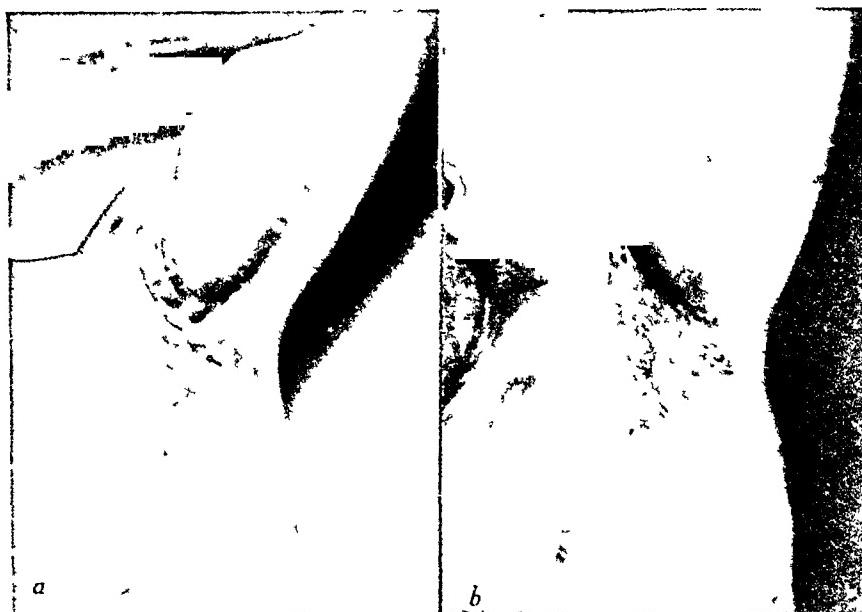
Fig. 8a. Hidrosadenitis suppurativa with an involvement of the left axilla of the long-standing type with the characteristic presence of cord-like bands, sinuses, undermining and ulceration; b, three weeks after operation showing the extent of the graft with practically a complete take of the graft.

epithelial tissue in the involved area may occur.

In a recent report by Brunsting, of twenty-two cases of hidrosadenitis suppurativa observed at the Mayo Clinic, the distribution was slightly higher in the male sex and the average age was thirty years. In approximately a third of the cases

In the eight cases in which the intradermal tuberculin test was performed the result was negative. The results of inoculation of guinea-pigs were negative in the five cases in which this procedure was employed. Bacteriologic reports in thirteen of the twenty-two cases showed a hemolytic streptococcus of the micro-aerophilic

type in six cases. Staphylococcus aureus and Streptococcus viridans were the most common organisms found.

FIG. 9. Appearance of an axilla one year after excision of an extensive area of involvement with hidrosadenitis suppurativa and immediate skin grafting.

PATHOLOGY

The apocrine sweat glands are characterized microscopically by the presence of two layers of cells, an inner of the cuboidal type, which is the active secretory cell, and an outer flattened type of cell. In the stage of active secretion, these glands exhibit numerous papillary infoldings, whereas in the resting stage the papillary infoldings are absent. The inner layer of cells has a distinctive acidophilic cytoplasm which is somewhat granular. The cytoplasm usually contains hemosiderin and a yellow pigment which probably belongs to the lipochrome group.

In the earlier stages of this disease it is usually possible, histologically, to demonstrate the primary involvement of the apocrine sweat glands. The infection disseminates by means of the lymphatic channels and tissue spaces throughout the cutaneous and subcutaneous tissues until in the later stages the sweat glands are no longer recognizable. The process is associated with the formation of abscesses and as the inflammatory process progresses in one region it tends to heal in another region so that in studying sections from this condition one may find in one region an abscess made up of polymorphonuclear leukocytes and lymphocytes, while in another, granulation tissue, and in still another, fibrosis with very little cellular infiltration. Associated with the abscesses there is frequently ulceration of the surface epithelium with the formation of sinuses. (Fig. 1a and b.)

TREATMENT

Hidrosadenitis of the axilla, the most common location of the infection, fortunately lends itself to surgical treatment. Surgical treatment is confined to those cases in which the condition primarily does not respond to conservative treatment, to cases of recurrent involvement and to those of long standing which have been neglected.

Special attention should be called to the group of cases of early axillary infection in which the condition does not respond to adequate primary conservative treatment. Surgical treatment should not be delayed too long as there seemingly is a vulnerability to infection of the apocrine glands in other locations. Further, it should be pointed out that after surgical excision of the infected axilla, there is a favorable response in other associated infected regions. This report of the surgical treatment of axillary hidrosadenitis is based on a review of the records of ten cases in which fourteen axillae were treated surgically. The first procedure of excision of the axilla and skin grafting was carried out at the Mayo Clinic in August, 1936. All the patients have shown satisfactory healing and the results have been most gratifying. In one case, however, there was a postoperative complication, a subpectoral abscess, which responded to incision and drainage.

The surgical procedure consists of excision of all the ulcerated or involved regions

of skin and subcutaneous tissue. In cases of minimal involvement the excision should include all the hair-bearing area. The excision is carried out by dissection en bloc and should include any fibrous or inflammatory regions in the fat and connective tissue as well. There is no contraindication to carrying out the procedure in the presence of purulent drainage and performing a skin graft primarily. (Figs. 2 and 3.)

After completion of the excision a split skin graft, preferably removed in one piece, is obtained from a convenient donor area such as the thigh or abdominal wall. The Paget dermatome facilitates the removal of the graft. (Fig. 4.) The graft is well perforated to permit leakage of serum, hematoma or any localized focus of infection. The graft is then sutured into position in its prepared bed; suture material should consist of fine silk or nylon. A continuous running suture is made completely around the graft, the overlapping edges of the graft being sutured to the normal skin. This procedure is followed by the insertion of a sufficient number of sutures through the body of the graft to prevent slipping. Care should be taken in the central sutures to avoid the deep structures in the axilla, or the graft may be sutured around its edge with interrupted sutures, which are left long in order that they may be tied over the material used for compression. (Fig. 5.) Since the advent of sulfanilamide, sulfanilamide crystals are sprinkled over the graft. From 150 to 225 gr. (10 to 15 Gm.) is used, depending somewhat on the size of the grafted area. This is then covered with perforated gutta-percha or perforated foiloid and followed by the application of saline wet dressings. The graft should be kept moist for at least three to four days or until the first dressing, which should be done not later than the seventh postoperative day. The time to do the dressing depends on the postoperative course of the patient. To facilitate moistening of the dressings subsequent to operation several perforated Dakin's tubes are incorporated in the dressing.

The most important feature in skin grafting is the maintenance of a continuous even pressure dressing and this may be accomplished by employing sea sponges or sea foam rubber. (Fig. 6.) For immobilization an abduction humeral splint, any metal right-angled splint or such material as thick quilting may be used.

When the graft has taken which usually is noted from the sixth to the eighth postoperative day, the sutures are removed. If any blebs or areas of infection have formed beneath the graft, these should be opened and, if much infection is present, the sutures should be removed and the areas of infection painted with a 5 per cent aqueous solution of gentian violet or a 5 per cent solution of silver nitrate. It is also well to expose the infected areas to the air and give light treatments daily while continuing the wet dressings.

The postoperative care of the grafted area should consist of the wearing of an abduction splint for a period of from three to four weeks continuously and at night for a period of three to four months. This procedure lessens the risk of contractures. Scar contractures have not occurred to any appreciable extent in this series of cases but when evident or with the appearance of keloid formation, roentgen therapy may be employed beneficially. (Figs. 7a and b, 8a and b and 9.)

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POSTOPERATIVE GASTRIC DRAINAGE*

QUANTITATIVE STUDY FOR AN INDICATION OF RE-ESTABLISHMENT OF GASTRO-INTESTINAL MOTILITY FOLLOWING GASTRIC OPERATIONS

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GASTRIC surgery, which until late in the nineteenth century was undertaken with certain misgivings, has increased in prevalence in recent years. This has been due not only to refinements in surgical technic but also to the improved methods in postoperative care that have led to a more favorable outcome. Continuous or intermittent suction applied to a tube passed through the nose or mouth into the stomach is an integral part of such care.

Since the stomach tube was popularized over a hundred years ago, there have been introduced a large and varied assortment of tubes for emptying the stomach. The Levine tube has perhaps met with the greatest favor. Likewise, numerous methods of applying suction to such a tube have been suggested. Of these the principle advanced by Wangensteen is as simple and effectual as any.

Postoperative intubation is advisable, following gastric operations, to protect suture lines against stress, to permit the patient to take water and other fluids after recovery from anesthesia, to prevent overdistention of the stomach with liquid and gas, and to rest the stomach until local edema and irritation have subsided. Regardless of the general condition of the patient, secondary edema will appear at the site of the operation and may delay gastric emptying for several days. Edema occasionally develops as a result of disordered body metabolism.

The overdistention that is observed may be due to any factor retarding gastric emptying time. It may arise from edema at the pylorus or around a newly formed stoma, or from diminished gastric activity due to reflex or other origin. The function of gastric emptying is taken over by an ectopic center if the pylorus is sectioned or if a gastroenterostomy or Billroth I type of operation is performed. After edema has subsided, any restraining influence on gastric motility, if such can be demonstrated, must be brought about by contraction of the intestine below the site of operation.

In the immediate postoperative period, patients who have been subject to gastric surgery must be carried along on parenteral fluids. The amount administered should be dependent upon the demands of the patient from the standpoint of fluid balance. The administration of parenteral saline increases gastric secretion as well as duodenal and biliary secretion, but to a lesser degree than does the lavage action of large amounts of fluid taken by mouth and sucked back by a tube draining the stomach.

Thus in patients who have had a gastric operation and are being maintained on parenteral fluids as well as on fluids by mouth, the amount of fluid that is removed from the stomach will be dependent upon several factors. The chief factor, of course, is the amount of fluid that is taken by mouth. Of less significance is the amount of parenteral fluid (saline or other solutions) that is being administered. Other factors are: obstruction that develops at a newly formed stoma due to operative or other edema, obstruction at the pylorus due to similar edema or pylorospasm, obstruction due to gastric or intestinal atony, and

obstruction due to intestinal contraction beyond the operative site. If gastric distention is to be avoided, tube-drainage of the stomach must be continued until such time as gastrointestinal motility is re-established.

The patient, suffering discomfort from the tube, and the surgeon, confronted not only with possible alterations in chemical balance from chloride loss through the tube but also with the problem of fluid-balance maintenance, are both interested in as early removal of the tube as is feasible. Various criteria for the re-establishment of motility which have been presented in the past are based chiefly on retention tests and have their disadvantages. They are usually "trial and error" procedures and entail the risks attendant on gastric distention in the early postoperative period. A simple method of determining such re-establishment, at which time the tube may be removed safely, is afforded if an accurate fluid-balance record is kept.

Such has been the plan of procedure since early in 1938 at the Abington (Pa.) Memorial Hospital. In addition, a Levine tube is passed, preferably preoperatively, through the nose into the stomach of every patient undergoing gastric surgery. Suction by the Wangensteen principle is applied to the tube postoperatively. On the fluid-balance record kept for such patients there is recorded item by item the amount, nature, time and route of all fluid intake and output. The amounts are summarized every twelve hours, thus giving a day and a night figure. Twenty-four-hour totals are likewise indicated. Parenteral and oral fluid intake are among the items noted as well as fluids lost by kidney and bowel. The degree of sweating is indicated. Thus at the end of each twelve or twenty-four hour period it is a simple matter to determine from such a record the changes in fluid balance for the body as a whole as well as the gain or loss as far as oral fluids are concerned.

When intake by mouth exceeds output by mouth (vomitus plus suction drainage) gastrointestinal motility is assumed to be re-established. For not only is the excess of intake over output being assimilated, but also an amount representative of gastric secretions. At such time the tube may be clamped off for increasing periods of time, and if there is no indication for further gastric drainage the tube may be removed. In the following series, after re-establishment of motility the tube was left in place for a period averaging about twenty-four hours.

The records of patients undergoing gastric surgery at the Abington (Pa.) Memorial Hospital during a five-year period (1934 to 1939) were analyzed to determine whether the re-establishment of gastrointestinal motility subsequent to gastric operations followed any definite time pattern. For the purposes of this study the exact time of removal of the tube had to be known. This was found in fifty-eight of the cases. The described fluid balance records were kept for the last twenty-one of the above fifty-eight cases. It is to the fifty-eight cases that attention is directed and to the twenty-one cases particularly.

If, for the sake of explanation, a curve is plotted for intake by mouth and a second curve is plotted for output by mouth as determined from the records, the discrepancy between the two represents the net differential which may also be plotted. When this latter curve falls below the zero line, motility is established. (Figure 1 gives the curves for a typical case.)

Table 1 includes all cases in which the duration of intubation was indicated. This is given for each type of operation encountered. Table 11 includes those cases in the first table which presented data not only on the duration of intubation but also on itemized fluid balance.

In Figure 2 are plotted net differential curves based on the twenty-four hour totals of fluid intake and output by mouth. These curves are averages for: (1) each operation of which there were four or more instances, (2) the remainder of the various operations and (3) the group as a whole. The similarity of the curves is noteworthy.

With the exception of those patients in which gastroenterostomy was the operation performed, the maximum degree of obstruction or the minimum degree of motility was reached on the day after operation. On the second day after opera-

tion the degree of obstruction, either mechanical or functional, remained elevated as indicated by the excess of output over intake by the oral route. In the case of gastroenterostomies, obstruction was observed to be at a maximum on the second
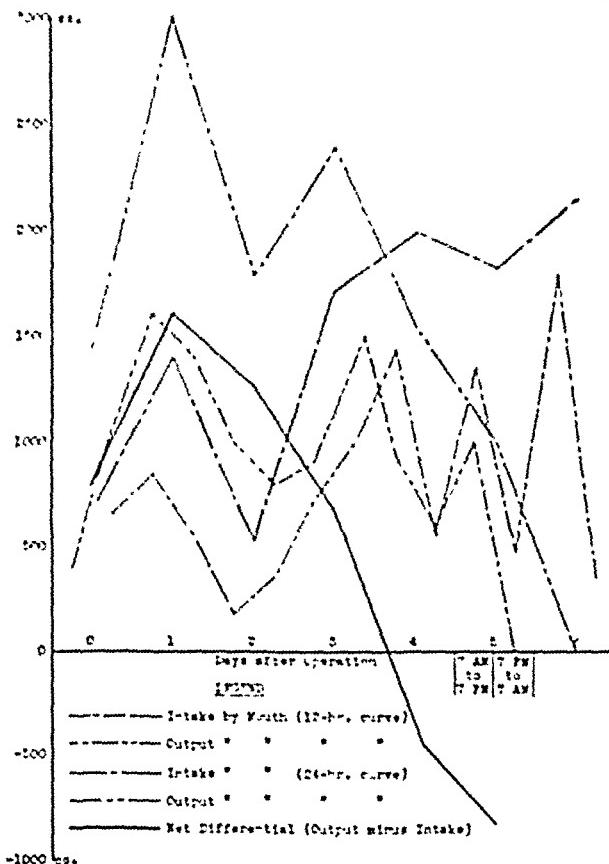
FIG. 1. N. H., Chart No. 38-4344. Bleeding duodenal ulcer; Finney pyloroplasty and suture of ulcer

TABLE I

Number of Cases	Operation	Duration of Intubation (Days)	Average
1	Gastro- and cholecystojejunostomy	8	8
7	Polya gastric resection	11, 6, 6, 6, 5, 5, 4	6
1	Gastrectomy and esophagojejunostomy.	6	6
2	Cholecystogastrostomy . . .	7, 5	6
1	Excision of gastric myosarcoma	6	6
2	Closure of gastrojejunocolic fistula	6, 4	5
28	Gastroenterostomy	11, 8, 7, 7, 6, 6, 6, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 4, 4, 4, 4, 4, 4, 3, 3, 3, 3	5
10	Finney pyloroplasty	7, 7, 6, 5, 5, 4, 4, 4, 4, 3	5
4	Closure of perforated ulcer	5, 5, 4, 4	4½
1	Gastrotomy and suture of ulcer	4	4
1	Heinicke-Mikuliez pyloroplasty	3	3
58		General average	5.2 days

day. The significance of the lag is not apparent. On the third day there is a subsidence of obstruction and on the crossed the zero line. This would indicate that by the fourth day, and let it be stressed that this is in the average case,
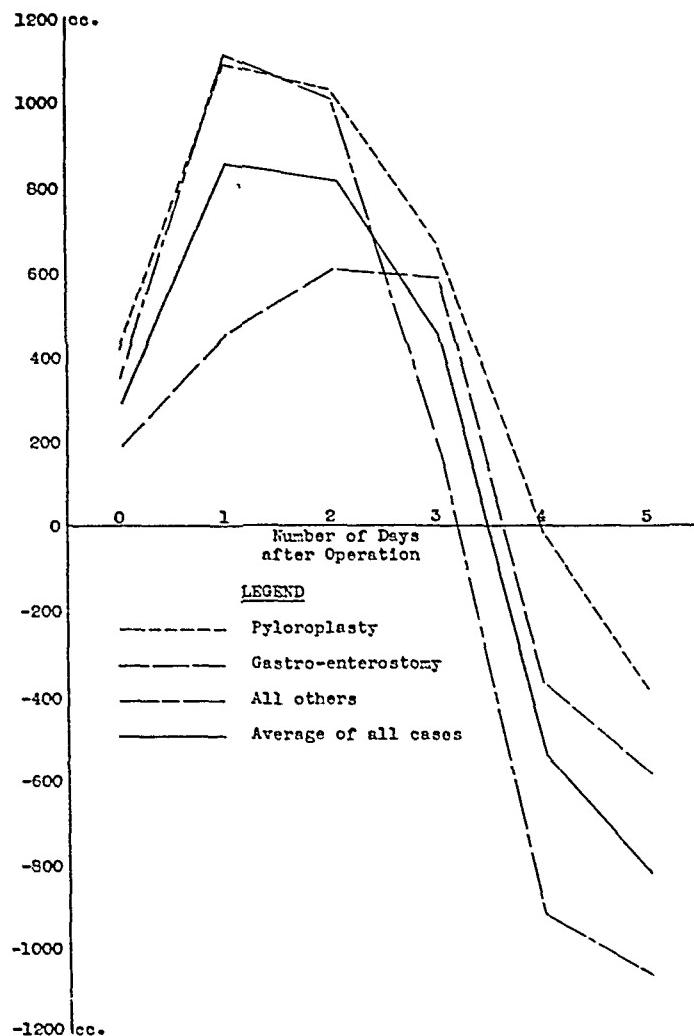
FIG. 2. Composites of net differentials.

TABLE II

Number of Cases	Operation	Duration of Intubation (Days)	Time for Differential to Reach Zero (Days)
1	Gastro- and cholecystojejunostomy	8	8
2	Polya gastric resection	11, 6	11, 4
1	Excision of gastric myosarcoma	6	5
2	Closure of perforated ulcer	5, 4	5, 4
4	Finney pyloroplasty	7, 5, 4, 4	5, 5, 4, 4
1	Closure of gastrojejunocolic fistula	4	4
8	Gastroenterostomy	7, 6, 5, 4, 7, 5, 3, 5	6, 5, 4, 4, 3, 3, 3, 2
2	Cholecystogastrostomy	7, 5	3, 1
21		Average....5.6 days	4.4 days

fourth day after operation the average net differential, not only for each of the various groups but also for the entire series, has motility becomes re-established. It is during the first day after operation that there is the greatest increase in obstruction. This

is quite natural as irritation is at a maximum. The cumulative action of those factors hindering motility subsides to the greatest degree during the fourth postoperative day. Then, as motility is reestablished, the curves of the net differentials level off and, after clamping or removing the tube, represent the oral fluid intake expressed as a minus value.

SUMMARY AND CONCLUSIONS

The prevalence and success of gastric surgery have increased in the last half century. Much of the gain may be attributed to improved postoperative care in which drainage of the stomach through one of the various tubes that have been presented plays an important rôle. Such drainage is adequately accomplished with the Levine tube to which suction is applied by the method of wangensteen. Drainage is indicated until gastrointestinal motility, interrupted by operation, is re-established. As a precautionary measure, the tube which otherwise might be safely clamped on the fourth day in the average case, should be allowed to remain in place for an additional twenty-four hours in those instances in which there is a question as to the permanent continuance of motility. The time of re-establishment of motility may be determined by analyzing a patient's record of fluid intake and output by mouth, when such a record is kept in detail following gastric surgery.

In a series of patients who were thus investigated, the time element with regard to motility after operation was established. Regardless of the type of operation on the stomach, motility in the average case was found to be at a minimum on the day after operation. By the fourth postoperative day, motility was found to be adequately re-established and subsequently continuous without remission.

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THE PREVENTION OF POSTOPERATIVE MENINGITIS BY INTRACRANIAL IMPLANTATION OF POWDERED SULFANILAMIDE*

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THE treatment of certain infectious diseases by the systemic administration of sulfanilamide has established itself as a notable achievment. This form of therapy has enjoyed no more spectacular success than in the treatment of meningitis, especially of streptococcic and meningococcic origin. Yet meningitis remains a dread complication of neurosurgical procedure, and methods useful in the reduction of the risk of meningeal infection may be fruitfully explored.

Bucy[1] has reported the value of sulfanilamide administered orally and parenterally in the prevention of probable meningitis, resulting from accidental contamination of the surface of the cerebellum during the drainage of a brain abscess. It was our purpose to test experimentally the efficacy of sulfanilamide in the prevention of meningitis, not by parenteral or oral administration, but by intracranial implantation of the powdered drug at the site of invasion of the organisms. That this form of administration might well be of value, was apparent from the work of Jensen, Johnrud, and Nelson[2] who demonstrated the prophylactic effectiveness of local implantation of sulfanilamide in the treatment of compound fractures. More recently, Rosenburg and Wall[3] found the intraperitoneal introduction of sulfanilamide powder of great value in the prevention as well as the treatment of peritonitis. Since this form of administration of the drug was found effective in the prevention of infection in a membrane as delicate as the peritoneum, its analogous use in the meninges was considered feasible.

The purpose of this work was to test the efficacy of sulfanilamide, locally applied, in the prevention of experimental postoperative infection of the meninges. A case report is presented to illustrate the use of this method in the prevention of meningitis following surgery for compound, depressed fracture of the skull.

EXPERIMENTAL PROCEDURE

A preliminary series of experiments with rats indicated that powdered sulfanilamide applied to the surface of the brain was neither toxic nor irritant. In the small group of rats studied, those in which the sulfanilamide had been implanted, survived; while the controls, not protected from the innoculation of a virulent culture, succumbed. The cultures used were predominantly Streptococcus hemolyticus. However, the operative procedure was so traumatizing in such a small animal, that extraneous factors rendered interpretation difficult. Cats proved pre-eminently desirable for this work, for in these animals, no mortalities occurred attributable to the operation alone.

Twelve cats, studied in six pairs, were used; one of each pair constituted the control animal. The infecting agent was obtained several days before each experiment from fresh pus obtained from patients with otitis media. The cultures were predominantly of streptococcic, containing occasional pneumococci and staphylococci.

To insure infection of the leptomeninges, the virulence of the cultures was strengthened according to the method described by

carefully opened stellate fashion, and the cortex gently scarified to insure contamination of the leptomeninges. After hemostasis

FIG. 1. A microphotograph demonstrating diffuse meningitis and inflammatory cortical change in a control animal. × 75.
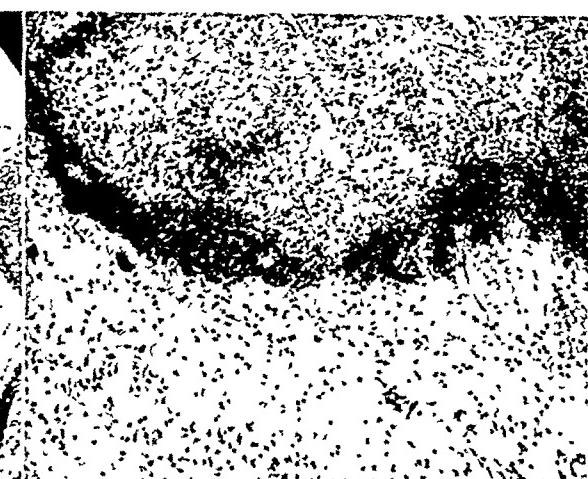
FIG. 2. A microphotograph demonstrating early subcortical abscess formation in a control animal. × 125.

Groff.[4] This entailed subculturing in blood agar at 37°C. for twenty-four hours with re-introduction of part of the melted agar into broth. Thus a virulent culture was obtained, which produced a fulminating infection without fail in each control animal. This is all the more striking since, when a discrepancy existed, the larger or better nourished animal of each pair was used as the control.

The animals were etherized, and a burr opening about the size of a dime was made in the temperoparietal area. The dura was

was complete, 1 cc. of the virulent culture was injected subdurally, the culture flowing somewhat beyond the limits of exposed cortex. The technic was identical in every animal, except that in one of each pair, the introduction of the organisms was followed by the subdural implantation of approximately ½ Gm. of powdered sulfanilamide. The powder thus applied covered the leptomeninges and cortex as well as dura. By delicate probing, the drug was brought just beyond the outer limits of the exposed brain to reach as much of the infecting

TABLE I
RAT PROTOCOL

Animal	Date	Culture	Sulfanila-mide	Course	Results
1.	12/20/40	0.25 cc. Hem. Strep.	None	Sick on 3rd day. Progressively worse; refused to eat	Died on 7th day, 12 27 40 Path. report: meningitis
2.	12 20/40	0.25 cc. Hem. Strep.	75 mg.	Well throughout	Living and well
3.	12/26/40	0.25 cc. Hem Strep.	None	Very sick in 24 hours, refused to eat	Died 2nd day, 12 28 40. Path. report. meningitis
4.	12/26/40	0.25 cc. Hem. Strep.	75 mg.	Well throughout	Living and well
5.	1/2,41	0.25 cc. Hem Strep.	None	Very sick in 12 hours	Died in 18 hours Path. report. early diffuse meningitis
6.	1 2/41	0.25 cc. Hem. Strep.	75 mg.	Well throughout	Living and well

fluid as possible. Closure was made of temporal muscle and skin with continuous catgut sutures. The animals were kept in warm cages, and received routine post-operative care. Table 1 and 11 illustrate the protocols and results in the rat and cat experiments, respectively.

EXPERIMENTAL RESULTS

The results summarized in the cat protocols (Table 11) exhibit a striking uniformity. All of the animals treated with sulfanilamide at the time of the operation and only at that time, survived for longer periods than the controls. Only one of the sulfanilamide-treated animals (No. 12) died, and this occurred eight days after the control animal had succumbed in twenty-four hours. At death, this treated animal was markedly distended and died apparently as a result of a fulminating toxemia due to secondary anaerobic invasion. There was no evidence of meningitis or cortical abscess. The brain appeared necrotic.

All of the control animals died with clinical and pathological evidence of meningitis. These animals demonstrated varieties of clinical and pathological pictures, ranging from death within twenty-four hours, from a fulminating invasion, to a maximum survival of seven days. Figure 1 is a microphotograph illustrating the suppurative meningitis obtained in cat No. 3. The sections show areas of polymorphonuclear infiltration, suppuration and necrosis, as well as new capillary formation and fibroblastic reaction. There is marked distortion of ganglion cells, edema and perivascular infiltration. Figure 2 illustrates a subcortical abscess seen in four of the six control animals. Most of the sections revealed dilated thrombosed vessels with perivascular polymorphonuclear leukocytic infiltration, focal necrosis and hemorrhage. Figure 3 is a microphotograph of the brain of one of the treated animals sacrificed for pathological study. Grossly the brain revealed no evidence of suppuration. On microscopic study, the meningeal vessels appeared somewhat engorged, and there

was slight round cell infiltration, possibly the result of scarification and slight irritation. There was no evidence of infection or

Fig. 3. A microphotograph demonstrating essentially normal dura and cortex in a sulfanilamide treated animal subsequent to scarification and injection with a virulent culture. × 100.

significant foreign body reaction. The cortex appeared well preserved.

CASE HISTORY

The patient, a boy of eleven, was admitted to the Montefiore Hospital in stupor two hours after he had sustained a head injury in a fall from a tree. On admission, his condition was poor. The head revealed a small scalp laceration in the right parietal region, through which cortical tissue oozed. Pupils were sluggish and reacted poorly to light. There was no gross paresis. The patient was given 100 cc. of hypertonic glucose intravenously, and a spinal tap was performed to relieve the stupor and extreme restlessness. Because of the possibility of incipient shock, operation was postponed until ten hours after admission. Tetanus antitoxin was given, and an .8 per cent sulfanilamide clysis instituted.

At operation, an extensive compound depressed fracture of the right parietofrontal region was disclosed. A radical débridement of the skull and cortex was carried out in accordance with the technic outlined by Munro. Because the fracture extended beyond the limits of possible exposure, the débridement

TABLE II
CAT PROTOCOL

Animal	Date	Culture	Sulfanila-mide	Course	Results
1.	1/20/41	0.5 cc. Hem. Strep.	None	Lethargic in 24 hours, with swelling over operative site, on 4th day very sick, large abscess present; cat in extremis 6th day; sacrificed	Path. diagnosis: suppurative meningitis; cortical abscess
2.	1/20/41	0.5 cc. Hem. Strep.	0.5 Gm.	Slightly ill 1st day, then well throughout; sacrificed in 12 days to examine brain	Path. diagnosis: slight injection of meningeal vessels
3.	1/31/41	1 cc. Hem. Strep.	None	Lethargic in 24 hours; swelling over operative site; eyes swollen, quite sick, does not eat; progressive signs of meningitis; died on 7th day	Path. diagnosis: suppurative meningitis; cortical abscess
4.	1/31/41	1 cc. Hem. Strep.	0.5 Gm.	Condition good next day; well throughout, sacrificed on 14th day for pathological study	Path. diagnosis: no evidence of suppurative meningitis or foreign body reaction; brain and meninges essentially normal
5.	2/4/41	1 cc. Hem. Strep.	None	Lethargic in 24 hours; swelling over operative site; eyes glassy; progressively worse; classical signs of extensive meningitis; died 6th day	Path. diagnosis: diffuse suppurative meningitis; cortical abscess
6.	2/4/41	1 cc. Hem. Strep.	0.5 Gm.	Condition good next day; well throughout	Still living; excellent condition
7.	2/11/41	1 cc. Hem. Strep.	None	Lethargic in 24 hours; on 2nd day, shallow respirations, paralytic rigidity hind legs; died on 3rd day in extreme rigidity	Path. diagnosis: suppurative meningitis; cortical abscess
8.	2/11/41	1 cc. Hem. Strep.	0.5 Gm.	Slightly ill 1st day; 2nd day much better, then well throughout	Still living; excellent condition
9.	2/14/41	1 cc. Hem. Strep.	None	Extremely ill, slight swelling over operative area. Died within 24 hours	Path. diagnosis: diffuse meningitis
10.	2/14/41	1 cc. Hem. Strep.	0.5 Gm.	Rather ill 1st and 2nd days, walks around, eats very little; condition improved 3rd day, then well throughout	Still living; excellent condition
11.	3/4/41	1 cc. Hem. Strep.	None	Dead in 24 hours	Path. diagnosis; diffuse meningitis
12.	3/4/41	1 cc. Hem. Strep.	0.5 Gm.	Ill 1st and 2nd days; on 3rd day cat eating a little and looks better; 7th day suddenly became worse, and entire body swelled rapidly before death on the 8th day postoperatively	Died 8 days postoperatively; no evidence of suppurative meningitis; brain appeared necrotic

could not be complete. Therefore, 4 Gm. of sulfanilamide powder were dusted into the wound. The powder was in intimate contact with the traumatized brain as well as the skull margins. Closure of the galea and skin was made with interrupted silk sutures without drainage. During the operation, the patient's circulation had been sustained with a transfusion of 500 cc. of blood, and his immediate postoperative condition was good. On returning to his room, the .8 per cent drip was re-instituted.

The patient's course in the hospital was quite satisfactory. A temperature of 103° (per rectum), noted forty-eight hours after operation, was the peak of the curve. At no time was there evidence clinically or on spinal fluid examination of meningitis; nor was there any evidence of a toxic reaction to sulfanilamide. The patient has been well since discharge from the hospital more than six months ago.

DISCUSSION

The clear experimental results demonstrate the efficacy of powdered sulfanilamide implanted intracranially in the prevention of meningitis. While the organisms were predominantly streptococci, pneumococci and some staphylococci were also present. Lockwood[5] stresses the importance of high concentrations of the drug at the site of contamination if the most beneficial results are to be obtained. He emphasizes the view that the future progress of chemotherapy rests on the ability of obtaining high concentrations at the desired site rather than increased drug specificity.

It appears that sulfanilamide is without harmful effect when locally applied in powdered form to the leptomeninges and cortex of cats. Russell and Falconer[6] proved that no appreciable damage was sustained by the local application of sulfanilamide powder to the rabbit's brain. They warn that excess of the powder will excite a foreign body reaction. In our experiments, estimation of foreign body reaction was difficult because of the cortical scarification and subsequent innoculation. We could, however, see no significant evidence of a process of this kind. Furthermore, clinical-

ly, this form of administration of the drug finds its most suitable application in the treatment of potentially infective cranial and intracranial injuries. In these conditions, the reparative changes are usually far more extensive than any demonstrable foreign body reaction to this chemical. Therefore, the foreign body reaction is a relatively unimportant consideration, especially when the possibility of severe infection exists.

In our patient, there was no clinical evidence of any toxic effect from the local application of 4 gm. of sulfanilamide to the brain surface, traumatized though it was. While our clinical case does not determine whether or not the intracranial use of sulfanilamide prevented meningitis, because of the surgery and parenteral administration of the drug, it does demonstrate that in this instance, it produced no untoward effects. It must be emphasized that the use of powdered sulfanilamide in potentially infected areas does not eliminate the necessity for a sound surgical prodecure, such as débridement of a compound fracture of the skull. However, when the débridement as in our case, is necessarily incomplete, local implantation of sulfanilamide may prevent a suppurative meningitis. Its use may well diminish the number of cases in which disfiguring surgery is deemed necessary in order to complete an extensive débridement of the skull. During war, this method may achieve its widest application in preventing the disfigurement of excessively radical surgery, or death from meningitis.

SUMMARY AND CONCLUSIONS

1. The intracranial implantation of powdered sulfanilamide is an effective and efficient method of preventing meningitis experimentally produced in cats by the subdural injection of a culture, predominantly streptococci. Thus, effective high concentrations of the drug, applied locally and prophylactically, when infection seems likely, may often spare healthy organs from intensive chemotherapy.

2. A case is presented illustrating the clinical application of this method, and demonstrating the apparent harmlessness of sulfanilamide dusted on traumatized cortex.

3. The value of this method in the prevention of infection of the meninges, especially in traumatic neurosurgery, is discussed.

We wish to express our sincere thanks to Dr. K. Y. Yardumian, Chief of the Laboratory, for his valuable advice during this investigation, to Mr. A. Levin for the microphotographic studies and to Miss Rhea Klein for her help with the bacteriological work.

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The only true hyperplasia of the connective tissue in the thyroid gland is found as the end result of a defensive reaction; that is, thyroiditis.

BIOCHEMICAL ASPECTS OF PREOPERATIVE AND POSTOPERATIVE TREATMENT*

ITS PRACTICAL APPLICATION

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ADVANCES in surgical technic were followed by an increasing recognition of the importance of improved preoperative and postoperative treatment. Increased knowledge in anesthesia, a better understanding of peripheral circulatory failure and shock, the prevention of pulmonary complications, thrombosis and embolism, and intestinal distention, were emphasized, and in the past decade have assumed their rightful place in the care of surgical patients. In the past few years, however, clinical and experimental research have also emphasized the significance and importance of a biochemical evaluation of the surgical patient, and it is this aspect with which this communication is concerned.

The categories to be discussed concern themselves with: (1) Fluid and electrolyte balance, (2) hypoproteinemia and its relationship to edema, its effect on gastrointestinal motility, and its relationship to wound healing and wound disruption, (3) nitrogen balance, and (4) vitamin C and its importance in wound healing and wound disruption. A prime purpose of this presentation is to show that the determination of all the above is a practical procedure to be carried out in the great majority of patients, and is not merely a theoretical consideration and one which requires highly organized laboratory and research facilities.

FLUID AND ELECTROLYTE BALANCE

Physiologic Consideration. There are numerous conditions which predispose to dehydration. Among the more common are prolonged diarrhea, vomiting incident to obstructive lesions, inanition secondary to ulcer or carcinoma, traumatic shock, etcetera.[13] We are, however, concerned here chiefly with surgical considerations. Electrolyte loss occurs chiefly through vomiting resulting from obstructing lesions of the gastrointestinal tract. The chloride ion is the principal electrolyte lost with gastric juice. If the loss of the chloride ion is sufficient, hypochloremia and alkalosis ensues. Similarly, the sodium ion is the principal electrolyte lost with pancreatic juice and bile, and if this loss is sufficient, acidosis ensues. Sufficient bile may also be lost via biliary fistulae to produce this picture. If the loss is from the lower reaches of the gastrointestinal tract, as from jejunostomy or ileostomy, there is a loss of unabsorbed electrolytes. In prolonged diarrhea, similar changes follow.

In the consideration of the physiologic aspects of patients in whom there is a disturbance of water and electrolyte balance, the *degree of hydration*, the *electrolyte balance*, and the *nutritional state* must be considered.

The water of the body is divided into three components: the intracellular and the extracellular, the latter composed of *interstitial* and *intravascular* portions. The interstitial portion is about three times as large as the intravascular portion, and its volume varies considerably in varying degrees of hydration, while the intravascular portion, or plasma volume is maintained at fairly constant levels. The important problem in the analysis of the extent of hydration is the determination of the volume of interstitial fluid and the extracellular volume. It is difficult to determine directly

the extracellular water, but it can be arrived at indirectly by the determination of the plasma. It has been shown[12] that the plasma volume up to a certain point, is maintained at the expense of the interstitial water during extracellular water loss, but beyond this the plasma volume diminishes with consequent hemoconcentration. Thus hemoconcentration and reduced plasma volume indicates a serious reduction of extracellular fluid. A change in plasma protein concentration, if protein has not been added or lost, may presume changes in plasma volume. Obviously then, determinations of these are important in determining the severe degrees of dehydration.

In the considerations of proper therapy, it will be apparent that the electrolytes replaced will obviously depend upon the electrolytes lost. With loss of chlorides, only moderate amounts of solutions are given, as here both water and electrolyte retention are greater. With sodium loss on the other hand, larger amounts may be given, as neither electrolytes nor water will be retained, obviating the danger of retention edema.[13] In the acutely ill and dehydrated patient it is sometimes insufficient to give sodium chloride alone, for at times the blood is found more concentrated after its administration, and here the use of adrenal cortical extract will help fix the sodium.[14] It will be shown that in hypoproteinemia, when there is already a fixation of the sodium chloride and water in the tissues, the use of adrenal cortical extract is obviously contraindicated.

It can thus be seen that the indiscriminate administration of fluids, either salt solution or even glucose, is not without hazard, and it is also reasonable to assume that the quality and quantity of fluid given must vary with each patient and with different states of fluid balance. For example, the renal function is impaired in marked dehydration, and the administration of large amounts of salt solution is often associated with edema. Thus for the correction of the former, glucose solution rather than salt solution is indicated, and

its administration results in an increase of renal blood flow, an increase of plasma volume, and does not usually predispose to edema. Thus is demonstrated the fallacy of the administration of salt solution under improper conditions. In dehydration, hypertonic fluids will be deleterious, for it is well known that hypertonic glucose solutions are effective in inducing dehydration. Also administration of excessive fluids even of *proper* concentration is to be avoided, for in patients with a reduced serum protein level, edema is likely to result.

Following these introductory remarks, it will be shown that the amount of fluid to be administered can be determined with a satisfactory degree of accuracy by one of several methods:

1. In the patient who is not vomiting, and can retain fluids by mouth, the problem is fairly simple. The usual fluid intake (including that in the diet) is approximately 3,000 cc. per day. If the urinary output is about 1,500 cc. daily, and the specific gravity 1.015, one may assume that the fluid intake and electrolyte balance is adequate.[1]

2. In the patient who cannot take fluids by mouth and must, therefore, receive parenteral fluids, several methods for determination of fluid requirements have been put forth: (a) *By calculation of total requirement for twenty-four hours.* The sum of the following represents the usual daily requirements: 1,500 cc. of water for urine, 2,000 cc. of water for vaporization, numerical replacement of fluid lost in vomitus, drainage from fistulae, hemorrhage, etc. If the patient is severely dehydrated, an additional 3,600 cc., or 6 per cent of the body weight may be given. (b) *By simultaneous determinations of chlorides and carbon-dioxide combining power.* These determinations indicate the total base, which according to Elkinton and associates[2] and Peters[21] is the important factor, as the total base determines the amount of water held in the tissues. However, the ratio of acid to base ions is important rather than just the total base concentration. In addi-

tion to dehydration there may be either acidosis or alkalosis. The determination of plasma carbon dioxide combining power and plasma chlorides, from which the total base may be calculated, as will be shown below, is important in following the electrolyte balance.

Methods of Determination of Chlorides and Carbon-Dioxide Combining Power. About 5 cc. of blood is drawn and placed directly into a Sanford-McGath hematocrit tube containing the proper amount of heparin. After centrifugation, the hematocrit is read. The protein can be determined from a few drops of plasma from its specific gravity by use of the Barbour and Hamilton's falling drop apparatus.[3] Residual plasma is used to determine the carbon dioxide combining power and chloride concentration. The mathematical calculations and interpolations necessary to obtain the appropriate figures for electrolyte determinations are beyond the scope of this presentation, and for the formulae, one is referred to other articles.[2]

Administration of Fluids. A simple method of giving parenteral fluids is the administration of physiologic saline in 5 per cent glucose in amounts equal to the gastric, biliary, intestinal, etcetera, loss, plus 5 Gm. of sodium chloride for urinary excretion, and 1,000 to 2,000 cc. of a 5 per cent glucose solution to equalize the insensible loss.

Although base loss is important, acid ions must not be overlooked; replacement is in physiologic proportions. About three-fourths of the total base requirement is given as isotonic saline and one-fourth as sodium lactate or bicarbonate. If the carbon dioxide combining power or plasma chlorides are reduced, these must be restored by the administration of more sodium chloride, bicarbonate, or lactate as needed, and alkalosis or acidosis avoided. This method of attack aims at obtaining normal physiologic concentrations of base and acid ions, and water.

(c) *By determination of plasma chlorides.* Coller and associates[5] calculate the amount of physiologic saline needed by the so-called "clinical rule": for each 100 mg. that the plasma chloride level needs to be raised to reach the normal of 560 mg. per cent, the patient should be given 0.5 Gm. of sodium chloride per kilogram of body weight.

This method offers a simple and adequate technic for the determination of necessary *electrolyte*. According to Elkinton,[2] however, this method is not completely satisfactory as it ignores total base as such and hemoconcentration as an indicator of serious loss of extracellular water and electrolyte. The importance of the latter has been brought out in the preceding paragraph.

If no dehydration exists, but nothing is taken by mouth, and parenteral fluids are required, 500 cc. of physiologic saline solution or Ringer's solution, with 2,500 to 3,000 cc. of 5 per cent glucose in distilled water, will satisfy the patient's requirements.

It might also be stated that in diarrhea and ileostomy drainage, the base loss is greater than the chloride loss; here one finds a nearly normal plasma chloride, but a low carbon dioxide combining power. If there is vomiting, the chlorides are of course reduced. In cases with such base loss, Hartmann has presented a method for fluid and electrolyte correction.[4] According to this author, chemical examination of the blood will determine the loss of water, chlorides, bicarbonate, and total fixed base, but other substances as calcium and potassium are not so indicated because their concentration in the blood plasma remains fairly constant. He emphasizes that the calcium and potassium should, however, be considered, and to accomplish this, Ringer's solution should be given. The bicarbonate content of the blood and body fluids can be restored by *separate* injections of sodium bicarbonate and Ringer's solution. However, instead of separate injections, if sodium lactate is substituted for sodium bicarbonate, the sodium lactate can be combined with Ringer's solution, as these two are *compatible*.

Ringer's solution is indicated when chlorides, sodium, potassium, calcium and magnesium have been lost. It is thus applicable in all forms of dehydration, and as has been previously stated, when large amounts of gastrointestinal secretions have been lost as by vomiting, diarrhea, fistula, etc., Hartmann suggests the giving of 80 to 100 cc. per kilogram of body weight.

Sodium lactate solution is indicated in specific amounts in acidosis. As it is generally used when the carbon dioxide content is under 25 volumes per cent, a routine dose of 10 cc. of the molar solution per kilogram of body weight, diluted with 5 volumes of distilled water, will tend to raise the carbon dioxide content by 25 to 35 volumes per cent.

Lactate-Ringer's solution is indicated in all types of dehydration as this solution relieves acidosis or alkalosis and is especially useful when chemical blood determinations are not available. It may be administered by any parenteral route. When severe dehydration and loss of electrolytes exists, an initial dose of 80 to 100 cc. per kilogram of body weight may be indicated. However, it must be emphasized that after this initial dehydration and loss of electrolytes is corrected, the daily dose of Lactate-Ringer's solution must not be over 25 cc. per kilogram of body weight. The remainder of the fluid requirements are met with 5 per cent glucose.

(d) Determination of *hematocrit, specific gravity of whole blood and plasma, and computation of plasma protein.* It has been shown that these give valuable information regarding the state of hydration.[10]

Hematocrit. The determination of the hematocrit or cell volume is important, as there is characteristically an increase, no matter what the cause of the dehydration. The normal hematocrit for the male averages approximately 46 per cent and for the female the average is approximately 41 per cent. The hematocrit also gives important information about the plasma volume. If there is no change in erythrocytes, either by hemorrhage or transfusion, successive

hematocrit determinations show changes in plasma volume.[20] The complete technic for these tests can be found elsewhere.[5]

Specific Gravity. That the specific gravity of whole blood and plasma varies with hemorrhage and edema, and with shock and dehydration, has been demonstrated.[11] Specific gravity determinations can be done by the simple method of Barbour and Hamilton.[7,8,9] According to this method, the normal average value of the specific gravity of whole blood is 1.0566 for males, and 1.0533 for females. The specific gravity of normal plasma is 1.0270, and this corresponds to a plasma protein of 6.83 Gm. per cent. The specific gravity is increased in shock and dehydration, and decreased in hemorrhage and edema.

Plasma Protein. It has been shown that there is a definite relationship between the the specific gravity of blood plasma and plasma protein content.[6] Knowing the specific gravity of blood plasma, the plasma protein content can then be determined by reference to appropriate tables. The further significance of this will be brought out more fully in the consideration of hypoproteinemia.

SUMMARY

Methods have been presented by which the state of hydration of patients can be determined with reasonable accuracy; and that when these determinations have been made, the administration of fluids, correct qualitatively and quantitatively, can be accomplished. The carbon-dioxide combining power, and chlorides, gives important, and probably the best data for accurate control, of course in conjunction with the clinical signs. That an understanding of these principles will aid substantially in restoration of fluid and electrolyte balance needs little additional comment.

HYPOPROTEINEMIA

Physiologic Consideration. An important function of plasma proteins is to maintain the colloid osmotic pressure of the

blood plasma. The osmotic pressure that the colloids exert against the capillary blood pressure prevents the fluid from leaving the capillaries into the surrounding tissues. A reduction of the colloid osmotic pressure causes a decrease in the ability of the plasma to retain water, and with this reduced plasma protein concentration, edema results. It has been shown that a depletion of plasma protein to the level of 4 to 4.5 Gm. per cent represents the critical level, and thus when the depletion is approximating this level, it can be reasonably predicted that edema will present itself. However, there are probably fluctuations in the figure.

Since in hypoproteinemia there is a lack of ability for plasma to retain water, injection of large amounts of various salt solutions obviously results in edema, whereas under other conditions, edema does not occur. This definitely illustrates that in hypoproteinemia there is a reduction in the ability to hold fluid in the blood, and a consequent escape and accumulation of abnormal amounts in the tissue spaces.[12] As the plasma proteins are diminished, there is a loss of fluid from the blood vessels, the edema at first being latent, and if continued, it becomes evident.[16] The mere replacement of fluid and electrolytes is insufficient without consideration at the same time of plasma proteins. In some instances a disturbed electrolyte balance takes place not because of a primary plasma protein deficiency, but because the capillaries have been so injured that plasma protein and crystalloids pass through the capillary walls into tissue spaces. Trauma and consequent oxygen lack frequently cause such increased capillary permeability. It has been shown that the fluid escaping at the site of burns closely corresponds in composition to that of serum,[18] and Beard and Blalock[19] found that the protein content of fluid lost as a result of burns, inflammatory processes, of distention of the intestine with interference of circulation, is similar to the protein content of plasma.

Although nutritional hypoproteinemia rarely leads to severe circulatory failure, its consideration and correction assumes definite surgical importance, for it will be shown that there exists a relationship between hypoproteinemia and certain postoperative complications.

With this as a brief basic explanation of the biochemical mechanics, those conditions which predispose to hypoproteinemia will be mentioned, and the resultant effects of hypoproteinemia of surgical significance discussed. Among the more common conditions leading to hypoproteinemia are deficient protein intake, deficient protein synthesis, hemorrhage, infection, extensive burns, loss by drainage, or in severe liver disease, in which the power to regenerate serum proteins is greatly diminished. In patients with ulcer or gastric cancer, because of restriction in diet for various reasons, there is undernourishment with protein starvation and ensuing hypoproteinemia.

A. *Nutritional Edema.* The capillary blood pressure tends to force fluids into the tissues while the colloidal osmotic pressure draws fluids from the interstitial spaces into the blood stream. In this reaction plasma protein is a dominating factor.[28] More detailed explanation of the mechanics can be found in other works.[29] Hence, because of the reduction of the osmotic pressure of the blood, there is a disturbance of water balance and a resultant peripheral, visceral and pulmonary edema, the latter often resulting in pneumonia.[17] Peripheral edema, manifested chiefly in the subcutaneous spaces is an early and frequent occurrence. Visceral edema will be discussed under gastrointestinal motility. Pulmonary edema can occur in a hypoproteinemic patient receiving small amounts of fluid, even though the patient is in negative water balance, emphasizing again the importance of hypoproteinemia.

B. *Gastrointestinal Motility.* As has been stated, when the plasma protein concentration falls below a certain level, the osmotic pressure which the plasma exerts is

reduced and fluid leaves the vessels, resulting in an increase in extravascular fluids, which if continued leads to edema.[22] In this process of edema the gastrointestinal tract is not excluded. It has likewise been shown that a reduction of the plasma protein of a dog will result in a marked increase in the gastric emptying time.[23] This in some instances becomes so prolonged that a technical defect in an anastomotic stoma is simulated. Persistent vomiting is often attributable to this cause. Disturbances in the motility of the gastrointestinal tract due to diminished plasma proteins are also emphasized by Barden and associates[25] and Mecray.[23] Restoration of serum proteins causes a prompt amelioration of these obstructive symptoms. It is well to remember also that hypoproteinemia can develop quickly following extensive operations upon patients who prior to operation appeared in good nutritional balance.[29]

C. *Wound Healing and Wound Disruption.* It has been shown that the healing of wounds follows a fairly exact mathematical formula.[26] In dogs rendered hypoproteinemic by diet or plasmapheresis, it was demonstrated that there was a delay in fibroblastic proliferation and consequently in wound healing. Contraiwise, in the absence of hypoproteinemia there was no delay in the healing of wounds.[27] More weight is lent to these conclusions when it is remembered that, as Ravdin[24] states "disruption is still encountered in wounds free from infection, in which hemostasis was excellent, in which trauma to tissues and tension was minimal, and unusual strain obviated," and this "strongly supports the concept that other factors of a general character play an important part in the failure of certain wounds to heal." The importance of serum protein in wound healing was forcibly demonstrated by Thompson,[30] who showed that even though there was still edema of the wound edges for some time after the serum proteins became normal, wound healing progressed.

Correction of Hypoproteinemia. All surgical patients should have their nutritional status determined, and if the serum pro-

teins are found to be diminished, normal levels should be reached prior to operation, if possible. This restoration is at times difficult, especially when there is impairment of regeneration. In these cases proteins or amino acids cannot be utilized for synthesis of serum protein. However, in most patients such a factor does not pertain, and there is no defect in the regenerative factors of serum protein. The hypoproteinemia is merely nutritional in origin.

In cases with chronic loss of the protein fraction of the plasma, protein-containing fluids are to be administered. A variety of substances have been recommended, among them being lyophileplasma, amino acids, acacia solutions, ascitic fluid, serum and plasma, and whole blood. All but the latter two will receive but brief explanation here. The plasma offers the most rapid avenue of correcting nutritional hypoproteinemia. *Lyophilized plasma* has been suggested.[36] Details of the lyophile process for those interested are described by Mudd and associates.[37] *Amino acids* likewise have been used, and more detail will be given in the discussion of nitrogen balance. *Ascitic fluid* has been used,[35] and some interesting observations have recently been recorded by Maes and Davis.[39]

Whole blood or plasma are chiefly used. Whole blood is especially useful when the hypoproteinemia is associated with anemia. It is important to give multiple, large, and frequent transfusions if a definite rise in serum protein is to be reached and maintained.[29] If no anemia is present, plasma or serum is superior to whole blood, because it does not overload the system with unnecessary corpuscles. The relative ease of obtaining ready serum or plasma, and the absence of reactions, presents obvious advantages over whole blood. Here likewise large amounts must be given.

SUMMARY

It has been amply shown that protein deficiency and hence hypoproteinemia assumes great importance in the consideration of the surgical patient. Edema, interference with gastrointestinal motility

and the failure of normal function of anastomotic stomas, as well as major disturbances in wound healing, are sequelae following its failure of correction. The edema is the result of hypoproteinemia and is due to a disturbance in the mechanics by which there is a reduction in the colloid osmotic pressure with a consequent decrease in the ability of the plasma to retain water. In view of the latter, the danger of administering salt solutions in the presence of hypoproteinemia should be kept in mind, as edema might be precipitated because the sodium chloride and water becomes fixed in the tissues.

In those cases in which there is no intrinsic condition which results in impairment of regeneration, substitute therapy is of definite value. Perhaps the best means of increasing serum proteins is offered by plasma transfusions.

NITROGEN BALANCE

In addition to establishing fluid and electrolyte balance and correcting hypoproteinemia, the importance of maintaining the patient in nitrogen balance is receiving deserved increasing attention.

Physiologic Considerations. Body proteins are being constantly destroyed, and obviously must be adequately replaced. If this is not accomplished, the patient will of course not be in nitrogen balance, as the nitrogen loss will be greater than the available usable nitrogen. This problem arises in the patient who must be fed parenterally. This group is represented by patients with repeated vomiting as in intestinal obstruction or peritonitis; or in those in whom oral feedings are unsatisfactory, as in intestinal fistula or severe ulcerative colitis with diarrhea, by virtue of the fact that sufficient food cannot be tolerated, or perhaps is excreted before being sufficiently absorbed, and the tissues thus do not receive any adequate supply of amino acids. Under these circumstances enumerated above, it becomes apparent that amino acids, if possible, must be given parenterally. That such can be done has recently been demonstrated.[31]

Amino Acids for Intravenous Alimentation. It has been shown that amino acids in the form of an enzymatic casein hydrolysate is utilized for the nutritional needs by patients[31,32] and that it can be given safely has been repeatedly confirmed.[31,33] Altschuler and associates[33] have shown that casein hydrolysate to which has been added 1.8 per cent tryptophane and 1.5 per cent cystine can be administered intravenously to postoperative patients without deleterious reactions, and the patient can be maintained in nitrogen balance when this amino acid mixture is substituted for protein in the diet. Also, amino acids were completely utilized and nitrogen balance maintained. Marked improvement was also noted in patients with nutritional edema.

Plasma for Alimentation. Plasma also can maintain the patient in nitrogen balance,[34] but has some important shortcomings as a means of *nitrogenous nourishment.* It would require 1,000 cc. of blood to represent the equivalent of 35 Gm. of serum protein, the latter being the minimum for a 70 kilogram adult.[31] The impracticability of this is evident. Furthermore, plasma supplies the protein for serum protein only, but it is likewise necessary for other tissues to be supplied, and this is accomplished only by amino acids, as the latter represents the form in which protein enters the blood stream. The protein must physiologically first be hydrolyzed to amino acids.

Method. For the amount of amino acid to be administered intravenously, Elman and Weiner state "with regard to the quantity of dextrose and amino acids needed for intravenous alimentation, a rough estimate should be made. For a 70 Kg. adult certainly 1600 calories should be given, and more if fever is present. Thus at least 400 grams of dextrose and amino acids should be injected. Of the latter, sufficient should be given to keep the patient in positive nitrogen balance. From the various statements in the literature, at least 0.5 Gm. per kilogram should be adequate. In the adult patients observed in which the excretion of nitrogen was

studied for a long period, 5 Gm. a day was the usual maximum output. This corresponds to an amino acid intake of over 30 Gm. In other patients the nitrogen needs are probably much greater."

Reactions from administration of amino acids have been minimal. It might be added that amino acids in solution have been prepared commercially.

SUMMARY

The importance of maintainance of nitrogen equilibrium has been brought out. A mixture of amino acids containing essential constituents is available and can be administered parenterally without untoward reactions.

VITAMIN C

The importance of protein as a factor in wound disruption and would healing has been emphasized. Protein deficiency, however, is not the only factor to be considered. It has been established that vitamin c deficiency is a contributing factor to this complication. It has been shown experimentally that this deficiency has led to poor healing of surgical incisions.

The basis for the relationship of vitamin c to wound healing is perhaps best briefly explained by Hartzell et al.[44] who quote Wolbach and state that "deficiencies of Vitamin C result in abnormalities of all intracellular substances having collagen as their basis, and that its absence prevents the formation of the matrices of white fibrous tissue, bone, cartilage, and dentin." Also, "in Vitamin c deficiency the pathologic picture is produced by resorption of intracellular materials in both growth and reparative reactions."

The fact is not lost sight of, however, of the part in poor wound healing and disruption played by faulty technic, unnecessary trauma, poor hemostasis and infection.

Patients with gastric and duodenal ulcer have been shown to have low vitamin c levels in blood plasma,[41] as well as patients with gastric carcinoma, biliary tract disease, severe diarrheas or with chronic sepsis. Significant also is the fact that the vitamin c plasma level drops considerably after operations *without* clinical signs of scurvy, even if the plasma level reaches zero. This obviously should impress one with the importance of keeping the vitamin c nutrition in mind but perhaps suggests the importance of prophylactic administration. It is also well known that a vitamin deficiency is rarely singular, and according to Lund and Crandon,[48] when large doses of vitamin c are given, thiamin hydrochloride, and nicotinic acid are also important. They give 1 Gm. of ascorbic acid, 30 mg. of thiamin hydrochloride, and 100 mg. of nicotinic acid daily for four days before operation. Vitamin therapy is carried out also postoperatively.

GENERAL SUMMARY

An attempt has been made to present some fundamental principles of therapy from a biochemical point of view. For those patients who cannot take fluid or food by mouth, parenteral therapy becomes necessary; and if the fundamentals presented are kept in mind, the water and electrolyte balance can be restored in each individual patient with considerable mathematical accuracy. The effect of protein deficiency has also been amply demonstrated. A reduction in the concentration of plasma proteins results in peripheral and visceral edema, and often explains the apparent failure of anastomotic stomas to function normally. Its relationship to wound healing is discussed. The importance of maintaining the patient in nitrogen balance is dealt with, and the exhibition of amino acids in patients not in nitrogen equilibrium, although not satisfactorily solved, is making headway. Experimental and clinical evidence is accumulating to demonstrate the importance of vitamin c in wound healing.

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PERITONEOSCOPY*

WITH SPECIAL REFERENCE TO WIDENING ITS APPLICATIONS

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PERITONEOSCOPY no longer requires introduction or apology. Its safety, simplicity and accuracy in abdominal diagnosis have been ably demonstrated by Ruddock,[1,2] Benedict,[3] Thieme,[4] Olim,[5] and others. There are now, in fact, over 300 peritoneoscopes in use throughout this country, the Ruddock peritoneoscope being the most widely accepted. I propose in this paper first to summarize briefly my experience with the peritoneoscope and then to describe some new or only slightly exploited applications.

PERITONEOSCOPY IN GENERAL

The reader is referred to the authors just mentioned for details of technic which consist, briefly, in four steps: local anesthesia, abdominal air inflation, insertion of the instrument through a small stab wound, observation and, when indicated, biopsy.

Two points deserve emphasis: the relative painlessness of the procedure and its safety. Although Priestly[6] recommends intravenous evipal, we have found local anesthesia quite satisfactory. Special note was made of the amount of pain during our last fifty-three peritoneoscopies: thirty-nine patients either had negligible pain or none at all, nine made moderate complaint and only five complained bitterly. Supplimental anesthesia was necessary just once. Four well sedated patients fell asleep during the procedure. The day following peritoneoscopy the patient is allowed up and around.

The safety of the procedure is well illustrated by Ruddock's[2] 900 observations with but a single mortality. There have been no known cases of peritoneal infection in the present series and I have encountered none in the literature. In one of our patients with terminal though atypical tuberculous peritonitis, a loop of ileum was punctured and the resulting fecal fistula doubtless hastened somewhat the inevitable fatal conclusion. Another patient in the last stages of syphilitic cirrhosis of the liver, lung abscess and cardiac decompensation expired two hours

	No. of Cases
Conditions involving the liver, such as cirrhosis, with or without ascites, carcinoma, etc	34
Jaundice of uncertain etiology	6
Splenomegaly	2
Suspected intraperitoneal tuberculosis	4
Pelvic pathology	9
Carcinoma of the colon (deciding operability)	2
Differentiating between appendicitis and salpingitis	5
Gunshot and stab wounds of the abdomen of questioned penetration	12
Miscellaneous conditions, including undiagnosable abdominal tumors, suspected hemoperitoneum, intra-abdominal adhesions, etc	6

after peritoneoscopy. Although autopsy revealed no evidence of injury, the procedure undoubtedly gave the final tip to the balance between life and death. Since these two casualties, I have avoided peritoneoscopy in patients with seriously reduced vital capacity and cardiac reserve and also in those suspected of generalized intra-abdominal adhesions. The mere presence of previous laparotomy scars, however, does not necessarily contraindicate peritoneoscopy.

SUMMARY OF CASES

Since the commencement of this study in December, 1939, eighty observations* have been made upon seventy-five patients. The distribution of cases examined is as shown in the table on page 668.

Table 1 condenses the results of the eighty examinations. Sixty-eight times a problematic diagnosis was confirmed or changed, or new and significant information was added. Laparotomy was obviated seventeen times and was definitely elected in eleven instances when the indication for operation was in doubt. (Table 1.)

should be found necessary, this preliminary procedure will not have added significantly in time or trauma to the operation. Some of the applications of peritoneoscopy about to be described will illustrate this.

Differentiation between Obstructive and Hepatic Jaundice. This differentiation is sometimes impossible in spite of all available diagnostic tests. Yet surgery is obligatory in the former case and contraindicated in the latter. Endoscopic visualization of the liver and gallbladder and biopsy of the former will, in the majority of these cases, make the diagnosis. Although this applica-

TABLE I

ANALYSIS OF EIGHTY PERITONEOSCOPIES

Diagnostic Problems		Deciding for or against Laparotomy		Other Uses
Clinical impression confirmed ...	38	Laparotomy avoided...	17	Puncture of ovarian follicular cyst for uterine bleeding, 2 cases; one successfully accomplished, one failure due to inability to find the cyst.
Clinical impression changed.....	14	Indication for laparotomy decided	11	
Significant information added...	16	Helped decide for or against operation.............	12	
Inconclusive*...........	12	No help in deciding for or against surgery†.............	9	
		Laparotomy not in question . .	31	

* Of these unsatisfactory results, eight occurred among the first sixteen peritoneoscopies performed with a foreoblique cystoscope. In still another case, before the biopsy forceps were acquired, syphilitic cirrhosis of the liver was missed. Twice among the earlier examinations the instrument could not be introduced into the abdominal cavity.

† Of these, seven followed as a result of "inconclusive" peritoneoscopic diagnoses. In another of these cases, scoped before the biopsy forceps had been procured, it could not be made certain by vision alone, whether masses in the liver were gummata or cancer.

NEW OR ONLY SLIGHTLY EXPLOITED APPLICATIONS OF PERITONEOSCOPY

There seems to be a prevailing opinion among writers on this subject that peritoneoscopy should not be used in any acute inflammatory or otherwise serious condition in which an adverse outcome might be blamed upon the instrumentation. Yet if peritoneoscopy in such a case can spare the patient the much greater procedure of exploratory laparotomy, and at the same time establish a diagnosis or decide whether or not operative intervention is necessary, it surely is indicated. If surgery

* The first sixteen peritoneoscopies were performed with a foreoblique cystocope, the remaining sixty-four with the Ruddock peritoneoscope.

tion in jaundice of doubtful etiology is doubtless tacitly assumed by most writers on peritoneoscopy, I have found definite reference made to it only by Olim[5] and Anderson.[8]

In the six cases of problematic jaundice in this series, the clinical impression was confirmed twice (hepatitis and cancer of the head of the pancreas).

In the third case, that of a twenty-six year old white female, the severity and type of abdominal pain, as well as a cholecystogram strongly suggestive of gallstones, made common duct stone a likely possibility. Finding a normal looking gallbladder and a liver normal in appearance except for some blunting of its margins

pointed to a diagnosis of acute infectious or "catarrhal" jaundice. Absence of biliary symptoms and jaundice for over nine months confirms this impression.

The last case was that of a fifty-seven year old colored female suspected of having, on the basis of pelvic findings and enlarged, irregular liver, cancer of the

FIG. 1. Liver biopsy, taken through peritoneoscope showing probable syphilitic hepatitis.
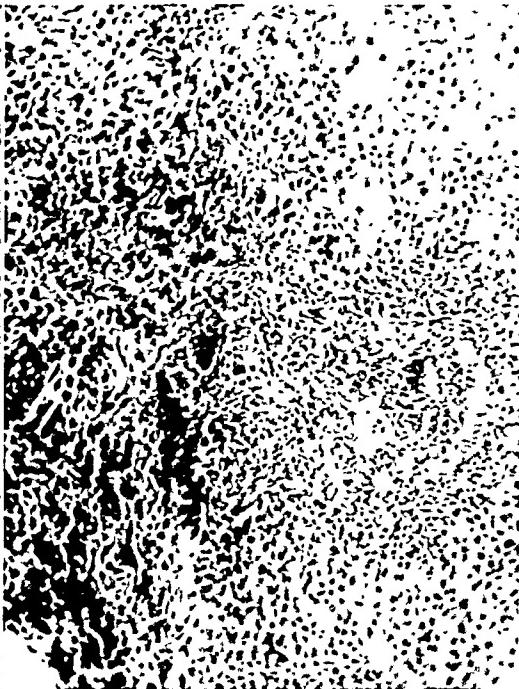
FIG. 2. Liver biopsy, taken through peritoneoscope showing bile obstruction, cholangeitis and early biliary cirrhosis.

Another patient, a thirty-seven year old female luetic who had been on arsenical therapy, was thought to have either arsphenamine hepatitis or infectious jaundice. Endoscopy and biopsy (Fig. 1) revealed syphilitic hepatitis.

The clinical impression of the fifth patient, an elderly man with painless jaundice, lay between cancer of the head of the pancreas and catarrhal jaundice. At peritoneoscopy a nondistended and apparently normal gallbladder rendered cancer of the head of the pancreas very unlikely. The liver was grossly not remarkable. A biopsy (Fig. 2) was reported, "Bile obstruction, cholangeitis and early biliary cirrhosis." The pathologist considered this compatible with the clinical syndrome of catarrhal or infectious jaundice and this diagnosis was further confirmed by the improvement and recovery of the patient.

cervix or uterus and obstructive jaundice from metastases. Through the scope a leiomyoma was found in the pelvis and a normal looking liver with dense adhesions around a gray, thick looking gallbladder. Peritoneoscopic diagnosis of common duct stone was verified at operation and the condition was successfully relieved.

Differentiation between Bleeding Peptic Ulcer and Ruptured Esophageal Varix. Surgical intervention is frequently indicated to control massive hemorrhage from peptic ulcer, especially in patients past fifty. In the occasional case in which cirrhosis of the liver with ruptured esophageal varix cannot be ruled out, visualization of the liver through the peritoneoscope should settle the diagnosis. This procedure, gently performed without even moving the patient from his bed, would seem to be less conducive to further hemorrhage and

more conclusive than the barium swallow recommended by Stalker and Gray[9] and others for diagnosing esophageal varices.
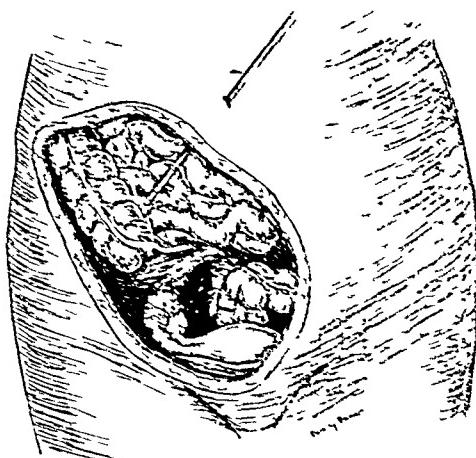
FIG. 3. Making the differential diagnosis between acute appendicitis and acute salpingitis. The appendix is normal, the right tube acutely inflamed and swollen.

Two cases of massive hematemesis admitted to our service this past year illustrate this point. The first patient, operated upon for bleeding peptic ulcer, was found to have a cirrhotic liver. Peritoneoscopy would have spared this patient an operation. In the second, a similar case, preliminary peritoneoscopy revealed a typical hobnail liver, thereby eliminating any question of laparotomy.

Differentiation between Appendicitis and Salpingitis. In this group were five patients in whom the diagnosis lay between acute appendicitis and acute salpingitis. Finding normal tubes by peritoneoscopy would demand operation unless the appendix could be satisfactorily visualized as normal. Discovering acutely diseased adnexae, on the other hand, would make the diagnosis of salpingitis and obviate surgery.

The first patient was admitted while a cystoscope was still being used for peritoneoscopy, and was one of two cases in which the instrument could not be introduced into the abdominal cavity. Exploratory laparotomy immediately following the unsuccessful attempt revealed little of pathology, either in the appendix or tubes. The operation and convalescence were without mishap.

The next three cases were completely successful. In two, a normal appendix and acutely inflamed adnexae were visualized.
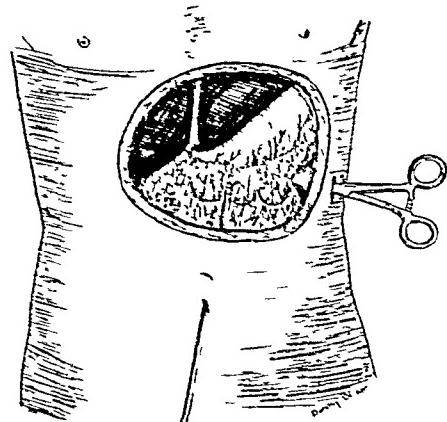
FIG. 4. Illustrating how a hemostat, poked through the suspected stab or gunshot wound, will indent and localize the underlying peritoneum for inspection through the peritoneoscope.

(Fig. 3.) In the third, although the appendix could not be seen, the diagnosis was settled by finding acute inflammation of the salpinx.

When the scope had been introduced into the fifth patient, free grayish purulent exudate was found, both in the pelvis and also in the cecal region and extending up in the right paracolic gutter. The right tube was only moderately injected and swollen, the right ovary normal. The main inflammatory process appeared to be in the region of the cecum, where there were plastic adhesions and what appeared to be the swollen base of the appendix with the remainder well walled off beneath loops of ileum. The patient was placed on the Ochsner regime and her recovery was uneventful. An interval operation four months later revealed a deformed, obliterated appendix with confirmatory microscopical evidence of previous inflammation. Tubes and ovaries were not remarkable. Although this patient would not have been peritoneoscoped if appendiceal peritonitis had appeared likely, the procedure in this case not only caused no harm, but obviated a laparotomy in the presence of peritonitis.

Ruling Possible Penetration in or out in Abdominal Gunshot and Stab Wounds. I have discussed this application of peritoneoscopy in a previous paper.[1] In 12 to 15 per cent of explorations for gunshot or stab wound of the abdomen the findings are negative. Peritoneoscopy can, in practically all cases, answer definitely the question of penetration of knife or bullet and thereby eliminate a number of needless operations. Figure 4 demonstrates how this is done. If the parietal peritoneum is intact, laparotomy is obviated; if a perforation is found, laparotomy follows. So far, peritoneoscopy has been performed in twelve cases of questioned abdominal penetration (nine stab wounds and three gunshot wounds) and in every instance has proved the presence or absence of penetration. Since penetration was present in only five cases, laparotomy was rendered unnecessary in the other seven. In one other patient with a gunshot wound, fluoroscopy revealed that the bullet had lodged in the right lobe of the liver, but it could not be determined whether or not active hemorrhage was present. Through the scope the absence of hemoperitoneum was assured.

Eleven of the above thirteen patients left the hospital without incident; the other two succumbed as a result of their injuries.

In the first of these, the bullet had passed through the lower chest and liver and had caused extensive hemoperitoneum. The patient progressed satisfactorily until the third postoperative day at which time the laparotomy wound disrupted. This accident was followed by bronchopneumonia, paralytic ileus and exitus on the eighth postoperative day.

Operation in the second case revealed perforation of the left femoral artery and vein as well as of three loops of jejunum. Death came the second postoperative day as a result of pulmonary embolism.

Rupture of Follicular Cysts of the Ovary for Uterine Bleeding. Twice in women unsuccessfully treated for uterine bleeding by hormone therapy and curettage, rupture of clinically diagnosed follicular cysts of the ovary was undertaken through the scope as a last resort before surgery. It was reasoned that this procedure might remove an excessive hormonal stimulus for bleeding. In the first case a small cyst of the right ovary was overlooked and the patient subsequently underwent hysterectomy.

In the second woman a retention cyst in the left ovary 8 cm. in diameter was punctured and 2 ounces of straw-colored fluid escaped. For six months her previously severe and prolonged menorrhagia gave place to scanty flow and occasional "spotting," and the endometrial biopsy, which previously had shown hyperplastic endometrium, now revealed anovulatory, hypoplastic endometrium. The patient was so well pleased that when the flooding recurred after the six months' respite, she returned for further treatment. Re-examination through the peritonescope revealed complete absence of the previous cyst and small sclerosed, hypoplastic-looking ovaries on both sides. A last trial with a new lactogenic hormone is being made before resorting to hysterectomy.

This last application is included merely as a suggestion for cases of intractible uterine bleeding before more radical procedures are employed. Further trials are contemplated as properly selected cases present themselves.

SUMMARY

Eighty peritoneoscopies upon seventy-five patients with a variety of conditions are summarized.

The following applications of the peritoneoscope, either new or little exploited, are presented: (1) Differential diagnosis of jaundice; (2) differentiating between bleeding peptic ulcer and ruptured esophageal varix; (3) differentiating appendicitis from salpingitis, (4) deciding whether or not gunshot and stab wounds of the abdomen are penetrating, and (5) rupture of follicular cysts of the ovary in women with

uterine bleeding and in whom other measures short of surgery have failed.

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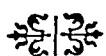
In simple uniform goiters of adolescence all the acini contribute to the increase in the size of the gland by increasing their colloid content equally. The result is an equitable increase of the gland in all its parts.

HEALING OF THE OPERATIVE WOUND IN SYPHILITIC WOMEN*

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UNTIL recently, comparative studies in the postoperative course and progress of wound healing in the syphilitic and nonsyphilitic patient has had a limited statistical approach. It was the general belief that the syphilitic patient was a poor surgical risk and that the operative wounds of these patients were prone to delayed union.[1] It has also been generally accepted that these undesirable features in the surgical syphilitic person could be avoided by the use of pre- and postoperative antisyphilitic treatment.[2]

Menninger,[3] in 1925, studied twenty-two surgical cases with strongly positive Wassermann reactions. He concluded that preoperative treatment is desirable and postoperative treatment advisable, although the effectiveness of such treatment as an aid to wound healing is undetermined.

In the same year, Goeckerman[4] presented a study of seventy-eight cases with syphilis, fifty of which had received treatment, twenty-eight none. He concluded that treated syphilitic patients could be operated upon with impunity and that old syphilitic patients were poor surgical risks only in proportion to the tissue damage.

Scheffey,[5] in 1931, studied ninety-two cases with positive and ninety-two cases with negative Wassermann reactions. He found that there was practically no difference in the wound healing between the positive and negative groups.

In 1940, Philip[6] reported a series of 164 patients operated upon; eighty-three of these had old syphilis and eighty-one had no evidence of the disease. All the syphilitic cases received six injections of salvarsan before operation. It is noted that even though these syphilitic patients were treated, they still showed 9.4 per cent more wound infections than the nonsyphilitic patients.

In this study, 4,717 cases, admitted to the Gynecological Service of the Harlem Hospital, were reviewed. A Kahn test was done in 2,815 cases; it was positive in 1,111 (39.4 per cent) and negative in 1,704 (60.6 per cent).

Of the total 4,717 cases, 1,603 consecutive laparotomies were performed. The great preponderance of operations was for pelvic inflammatory disease and fibromyomas; the remainder for ectopics, ovarian cysts, tumors and pregnancies in tubercular patients.

From this group of 1,603 laparotomies, 930 cases that fitted the following criteria were selected for study: (1) Each case had a blood Kahn test made; (2) each case had a laparotomy performed for a gynecological complaint. No other surgery, except appendectomy, was performed at the same time. (3) At the time of operation no patient showed signs or symptoms of primary or secondary syphilis. (4) No patient received immediate pre- or postoperative antisyphilitic treatment. (5) Operations in which intra-abdominal or skin drains were used, were excluded. (6) No syphilitic lesions were incised at the time of operation.

As a rule the history and physical examination were not sufficient to make the diagnosis of syphilis. Therefore, what has actually been done is to make a study of the operative wounds in patients with positive and negative Kahn tests.

Of the 930 selected laparotomies, 450 gave Kahn positive and 480 Kahn negative reactions. In the positive group of 450, fifty-four (12 per cent) had a one plus reaction. To be accurate these tests should have been repeated. However, according to Kolmer[7] a faintly positive Kahn reaction should be considered the first link in the chain of syphilitic diagnosis. Therefore, these fifty-four cases were considered to be positive in this series. It is hoped that the weakly positive cases that were actu-

TABLE I
POSTOPERATIVE WOUND AND THE KAHN TEST

	Positive Kahn (450 Cases)		Negative Kahn (480 Cases)	
	No.	Per Cent	No.	Per Cent
Normal wounds.....	363	80.6	399	83.1
Collection of serum..	7	1.55	10	2.08
Infections..........	74	16.4	61	12.9
Dehiscence.........	2	0.44	2	0.41
Eviscerations*......	1	0.22	5	1.01
Fecal fistulas.......	3	0.66	3	0.61

* In the entire group of 1,603 laparotomies there were eight eviscerations. The presence of six eviscerations in the 930 selected cases may be misleading, if the complete group of 1,603 is not considered. Five of the six cases of evisceration occurred within a short period of time (three months) and were probably due to faulty technic.

ally negative and the negative results in chronic syphilitic patients would statistically cancel each other.

In the 930 selected cases, other systemic diseases co-existent with the syphilitic infection, included tuberculosis, diabetes and rheumatic fever. This group is not large since practically all these operations were elective, and operation was avoided where serious systemic disease was present.

Preoperatively, all cases had complete physical examinations, weekly urine examinations, complete blood counts, sedimentation rates and blood pressures. A Kahn test was done routinely on admission.

Patients who had pelvic inflammatory disease were not operated upon until Simpson's rules were fulfilled, that is, a

two-week period had elapsed during which time the temperature was normal, the blood count normal and the sedimentation rate within normal limits. In the Harlem Hospital Gynecological Clinic, operations were performed on patients with pelvic inflammatory disease who had a sedimentation rate of 18 mm. in one-half hour. This is a shorter time than most clinics employ and may be a factor in the fairly high incidence of infection that appears in Table I.

ANALYSIS OF THE SEVENTY-FOUR WOUND INFECTIONS IN THE 450 PATIENTS WITH A POSITIVE KAHN TEST

Duration in Days	No. of Cases
1–5	31
6–10	17
11–15	7
16–20	6
21–25	1
26–30	3

Dehiscence—2 Cases, one a reoperative case, and one an uncomplicated supracervical hysterectomy.

Eviscerations—1 Case, this occurred on the ninth day following an operation for fibroids, intraligamentous cyst and numerous adhesions.

Fecal Fistulas 3 Cases.

1. Fifteenth day—case with adhesions between sigmoid and uterus, ovarian abscess opened at operation, no drainage.
2. Twenty-second day—fundectomy done on patient with pulmonary tuberculosis, postoperative peritonitis.
3. Ninth day—case with ileum adherent to a tubo-ovarian abscess. Serosa of ileum sutured. (Cases 1 and 3 both should have had abdominal drainage. These were probably errors in surgical judgment.)

ANALYSIS OF SIXTY-ONE WOUND INFECTIONS IN THE 480 PATIENTS WITH A NEGATIVE KAHN TEST

Duration in Days	No. of Cases
1–15	16
6–10	21
11–15	14
16–20	7
21–25	1
26–30	1

Dehiscence 2 Cases.

Eviscerations 5 Cases.

1. Seventh Day—hysterectomy and postoperative diabetic coma.
2. Fifth Day—fibroids with excess ascitic fluid.
3. Eighth Day—fibroid uterus, chronic salpingitis and hemorrhagic cyst of the ovary.
4. Fourth Day—intraligamentous cyst removed.
5. Tenth Day—appendectomy in patient with intra-uterine pregnancy.

Fecal Fistulas 3 Cases.

1. Ninth Day—case with adhesions between uterus and adnexae; adhesions separated, pus spilled from abscess.
2. Ninth Day—case with numerous adhesions in a "stony hard pelvis"; hysterectomy and salpingectomy done.
3. Patient operated upon in November, 1935; discharged as cured with no fistula; re-admitted to the hospital in April, 1936, with a fecal fistula.

DISCUSSION

From these charts the following facts are noted:

1. In this series, as well as in those of other authors, Scheffey, Goeckerman and Philip, the incidence of wound infections is slightly higher in the group of cases with positive Kahn reactions than in the negative Kahn cases. The slight differences noted, however, are of questionable statistical significance. There is little difference in the severity of the infections in the two groups, as measured by the duration of the infection and the length of the hospital stay.

Fecal fistulas were of equal numbers in both groups, and were caused in most instances by the separation of adherent loops of gut, postoperative peritonitis or

the escape of pus into the peritoneal cavity. In several of the cases that developed fecal fistulas, poor surgical judgment was used in that indicated abdominal drainage was not employed.

2. Of the patients admitted to the Harlem Hospital Gynecological Service, approximately 91 per cent are negroes. Therefore, the 450 laparotomies studied, were done largely on negroes who had a positive Kahn test with asymptomatic syphilis. The problem, as to whether or not asymptomatic syphilis in the negro surgical patient takes a more benign form than in the white patient, requires careful consideration. If this is true, it may explain the wide difference between the statistics presented by Menninger, Philip and others, and the series of cases here presented.

3. No preoperative antisyphilitic treatment was given in the cases reviewed. In figures presented by other authors, in which immediate preoperative antisyphilitic treatment was given, the percentage of wound infections was greater in the Kahn positive group than it was in our series of untreated syphilitic cases. It has been our opinion that there is reactivation of a dormant syphilitic infection when insufficient preoperative treatment is given. A limited number of patients were treated and the results lead to the conclusion that antisyphilitic treatment should not be carried out preceding the operation, unless a full course of treatment is given. All positive Kahn cases are referred for treatment, after discharge, to the Syphilitic Clinic.

CONCLUSIONS

1. In 4,717 admissions to the Harlem Hospital Gynecological Service, the Kahn test was done in 2,815 cases and was positive in 1,111 or 39.4 per cent.

2. Nine hundred thirty consecutive laparotomies that fitted certain criteria were reviewed. In 450 of these cases the Kahn test was positive, and in 480 it was negative.

3. In the Kahn positive group, the percentage of wound infections was 16.4 per cent. In the Kahn negative group it was 12.9 per cent.

4. Eviscerations and fecal fistulas had no apparent relation to the presence of syphilis.

5. The presence of latent syphilis, treated or untreated, presented a slight additional risk as far as wound healing and morbidity were concerned.

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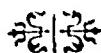
Goiters in children show certain similarities and differences which in a measure distinguish them from goiters in the adult. As is so often true with the diseases of childhood, goiters in children appear in the simplest form, uncomplicated by other diseases; and, particularly important in the study of goiter, they are uninfluenced by emotional states.

CONGENITAL DUODENAL OBSTRUCTION

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CONGENITAL anomalies of the intestinal tract are frequently encountered by pediatrists, roentgenologists and surgeons. In reviewing some of the literature written on this subject, the writer finds a great number of articles on malrotation of the mesentery, atresias and congenital bands which are the most frequent causes of congenital duodenal obstruction and also obstruction at various levels of the intestinal tract.

Since these abnormal conditions affect the intestinal tract at various levels and often in multiple sites, particularly in babies, every case encountered is a problem of absorbing interest. Although the final results in the treatment of these malformations are discouraging in a high percentage of cases, one should always entertain the hope that such obstructions may lend themselves to correction by relatively simple or safe surgical procedures. According to Webb and Wangensteen the first case of intestinal malformation was reported by Calder in 1773.

Simpson suggested faulty development of the sympathetic nervous system of the gastrointestinal tract as a cause of congenital anomalies. Segmental arrest of developmental accidents, such as intussusception or volvulus, failure of development of, or decrease in sufficient blood supply to certain segments, and fetal disease, such as peritonitis or localized enteritis, were also enumerated by him as theories.

Haymond and Dragstedt divide the process of intestinal rotation into three stages:

"During the fifth and tenth week of intrauterine life while the mid gut lies in the umbilical cord, the intestine increases rapidly in length forming an S-shaped flexure.

"The second stage is completed by the tenth to the eleventh week as the mid gut is returned to the abdominal cavity and the cecum reaches the right groin.

"The third stage is concerned with the fixation and fusion of the various portions of the intestine in their adult position."

Since Ladd published a series of cases successfully operated upon for malrotation of the small intestine in 1932, many authors have reported instances of this anomalous condition corrected by the method described by him which consists of untwisting the volvulus and severing the extrinsic bands attached to the upper jejunum and terminal ileum.

Elam reported three cases of duodenal obstruction due to an entire volvulus of the small intestine and congenital bands occluding the upper jejunum and terminal ileum. He expressed the belief that the defect was a failure in the third stage of intestinal rotation associated with an attachment of the terminal ileum to the upper jejunum in the left upper abdomen. All three of his patients were cured by carrying out Ladd's procedure.

CASE REPORTS

Case 1. Baby R. T., male, aged six weeks, was admitted to Sternberger Children's Hospital on the pediatric service of Dr. M. Y. Keith, with whom the writer saw the patient in consultation on November 5, 1934. The child was markedly undernourished and extremely dehydrated. Although this baby was normal at birth, and weighed nine pounds when he began to vomit on the tenth day, his weight had varied during the periods of vomiting and periods of relief until it had decreased to six pounds and three ounces at the time of admission. Obstipation was associated with these attacks of vomiting, no results being obtained with laxatives or with enemas. The vomitus

consisted of food which had been taken from a few minutes to three or four hours previously. It was frequently bile-stained.

jejunum several dense bands of adhesions were found constricting the intestine. Upon division of these bands a loop of distended jejunum was
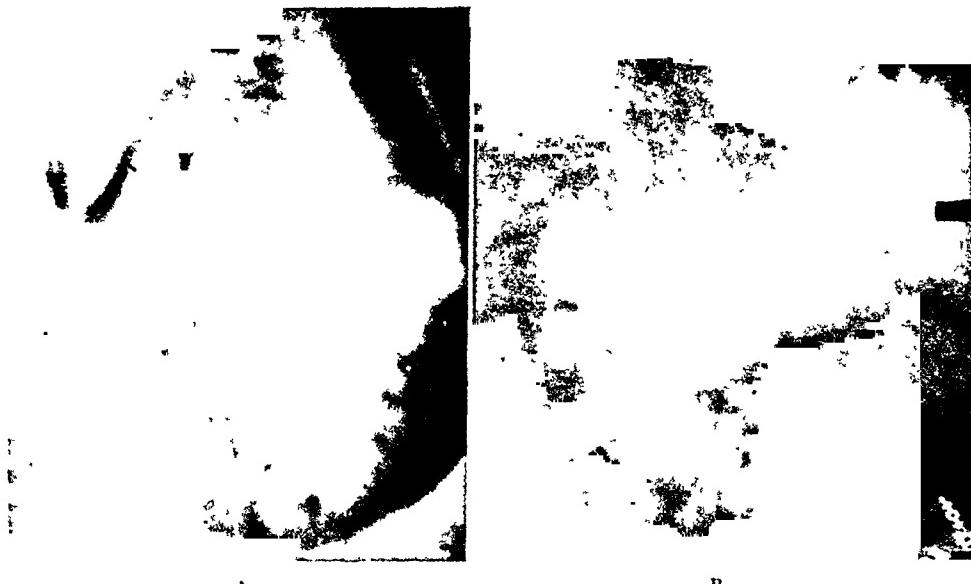
Fig. 1. A, x-ray photograph before operation; B, film made nearly six years after operation.

After sufficient parenteral fluids in the form of Hartmann's solution and transfusions of blood had been administered, a gastrointestinal study was made by Dr. B. E. Rhudy. During this study the stomach and duodenum were found greatly dilated, the barium stopping abruptly in the duodenojejunal area. Serial plates, however, showed that some of the barium passed through this constricted area into the lower small intestine but much of it was regurgitated and a considerable portion of the meal remained in the stomach at the end of six hours.

Following this x-ray study, apparently as a result of the heavy material ingested, the baby ceased to vomit and began to have fairly normal bowel movements. Because of this improvement in the patient's condition he was allowed to leave the hospital.

Two weeks later, however, the vomiting and obstipation recurred, resulting in a very rapid loss in weight and strength with marked dehydration. At this time he weighed only six pounds and twelve ounces. X-ray studies again showed definite obstruction in the duodenojejunal area which is seen in the accompanying x-ray photograph in Figure 1.

After the usual preoperative measures, an exploratory incision was made with the following findings: The stomach and entire duodenum were greatly enlarged and distended with gas. At the junction of the duodenum with the

found herniated into the supraduodenal fossa with constriction of both barrels of the loop by the bands, causing an almost complete obstruction. When these bands of adhesions were divided the loop was released. Following this procedure there was distention of the jejunum below this point.

In the region of the lower ileum, however, the mesentery was found twisted, was approximately one inch thick and contained veins as large as a lead pencil; this, with a brawny color to this portion of the gut, suggested an obstruction to the return flow in these vessels. Evidently this was a result of a fixed mesentery which had failed to rotate. A portion of the ileum passed under this thickened mesentery and, although it could not be readily traced, it appeared partially obstructed by thick bands of adhesions above the point of entrance and at the exit where it tunneled under the mesentery. It was not possible to rotate the mesentery because of its fixation to the posterior abdominal wall. The cecum and appendix were in the normal position.

At this stage of the operation the patient ceased to breathe but after stimulants were given and the hugely dilated stomach deflated by knife puncture respiration was resumed. His condition continued to improve and he left the operating room in fair condition.

With the exception of one period of vomiting, obstipation and formation of a fecal impaction
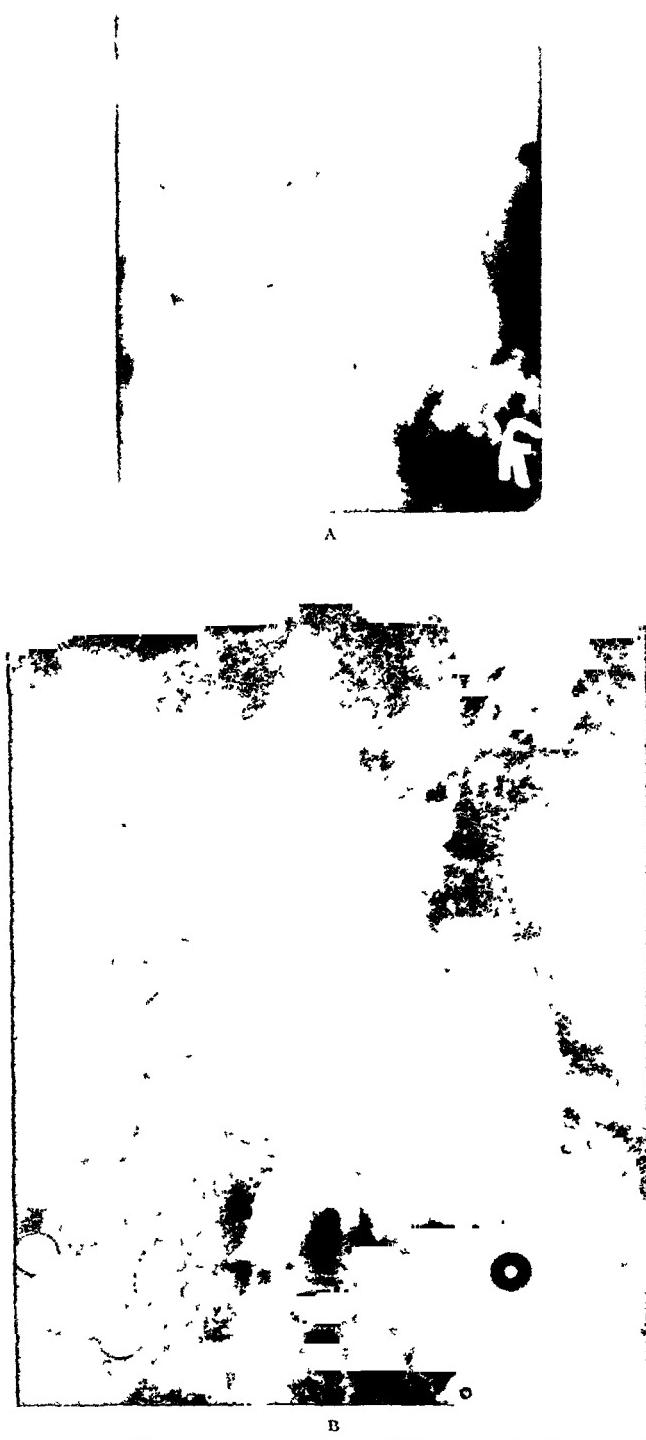
FIG. 2. A, film taken seven hours following a barium meal before operation; B, x-ray three and one-half months following operation.

a few days after operation, convalescence was normal. At the present time, July, 1940, this patient is robust and apparently well, having been free from any gastrointestinal disturbance since his discharge from the hospital.

Case ii. C. F., male, aged twenty, was admitted to the Wesley Long Hospital on April 5, 1940, because of empyema and attacks of vomiting. The empyema resulted from a lower left lobectomy for infected congenital cysts of the lung.

Since the age of ten he had suffered with occasional attacks of heartburn, sour stomach, eructations and periods of persistent vomiting. Although the heartburn was relieved by soda, there were no other symptoms suggestive of peptic ulcer. For the past six months these attacks of vomiting lasted from one month to six weeks.

Upon examination he was found to be dehydrated, emaciated and weighed about seventy-five pounds. The empyema was satisfactorily drained but vomiting of all food continued.

X-ray examination by Dr. E. D. Apple showed an obstruction of the descending loop of the duodenum. The stomach was low and atonic.

Following the usual preoperative preparation, abdominal exploration was performed April 24, 1940. The duodenum, in its first and second portions, was about two inches in diameter. Because of the patient's precarious condition it seemed unwise to attempt exposure of the third portion of the duodenum which contained the obstructive lesion. The duodeno-jejunal angle was not involved. Therefore, a posterior duodenojejunostomy was performed, following which an uneventful convalescence ensued. Complete relief with a rapid gain in weight followed this procedure.

DISCUSSION

In one of the cases cited in this paper there was an apparent malrotation of the small intestine but the peritoneal attachments were so firm and the mesentery so short or absent in the lower ileum that

untwisting was not possible. However, this congenital defect evidently did not interfere seriously with the lumen of the lower ileum since no further symptoms of obstruction have occurred within a period of six years following the operation.

The nature of the obstructing lesion in the second patient is not known. Although it is possible that contraction from an old ulcer in the third portion of the duodenum may have been the cause of obstruction, no definite ulcer symptoms could be obtained. Both the history and location of the obstruction lead the writer to believe that the obstruction in this patient was due to a congenital lesion.

SUMMARY

Two cases of upper intestinal obstruction are presented. In one patient there is no question but that the obstruction was of congenital origin because of the findings at operation and the fact that the symptoms dated back to within ten days of birth. Also, other congenital anomalies of the intestinal tract with arrested rotation of the mesentery were found at operation. In the second case there is much evidence that the obstruction is also of a congenital nature because of the history and the fact that this patient had congenital pulmonary cysts which required lobectomy.

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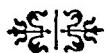
POSTOPERATIVE EVISCERATION*

A RÉSUMÉ OF THE LITERATURE AND REPORT OF FIVE CASES

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OUR interest in wound disruptions was stimulated by the occurrence of five cases on the gynecological service of Harlem Hospital within a two-month period. These were the sole disruptions observed in 1,543 consecutive laparotomies during a three-year period. Many terms have been used in the literature for this condition such as, (a) postoperative evisceration, (b) dehiscence of abdominal wound, (c) broken-down abdominal wound and (d) postoperative rupture. This paper is concerned only with those in which there were actual protrusion of the intestines or omentum.

A study of the literature shows that the suggested etiological factors may be grouped as follows: (1) *Increased intraabdominal tension;* (2) *faulty technic,* (a) faulty material, (b) improper closure of peritoneum, (c) drainage, (d) type of incision, (e) factors attributed to the surgeon; (3) *metabolic disturbances,* (a) diabetes, (b) malignancy, (c) syphilis, (d) other maladies with toxemia, (e) nutritive anemis, and (4) allergy. Most writers consider evisceration to be due to a combination of factors rather than to one single cause. Their theories will be considered under the heading upon which they lay most stress.

INCREASED INTRA-ABDOMINAL TENSION

Milbert agrees with Freeman, that emphasis on the etiological importance of age, sex, seasonal incidence, primary illness and allergic phenomena is "begging the question." Disruptions represent a failure of the suture line to hold, whether due to suture material or to abuse, with associated increase in abdominal pressure. Without the factor of excessive intra-abdominal pressure, an inherently weak wound might escape disruptions.

In a series of 7,892 laparotomies, H. Koster and L. R. Kossman believed that cough causing increased abdominal pressure was a disruptive factor in fourteen of the seventeen cases. Glasser states that in 3,234 laparotomies increased intra-abdominal pressure was the primary factor in eight cases of evisceration.

Many investigators have attributed evisceration to increased abdominal tension. Cough, (Koster), distention, (Colp), hiccough and sneezing, (White), all of these raise intra-abdominal pressure and place a strain upon the suture line. Patients (Jenkins) who are delirious or unruly, who get out of bed shortly after operation, who thrash about, who are difficult to control while coming out of anesthesia all put an undue strain on the incision. Two instances of audible breaking of the suture under such circumstances have been reported by Ries.

FAULTY TECHNIQUE

1. *Faulty Material.* The controversy of absorbable versus nonabsorbable sutures arises quite frequently in discussions regarding the prevention of postoperative evisceration, however, disruptions have been found to occur regardless of whether wire, linen, silk, silkworm or catgut is used. Reis has had an excellent record in a limited series of cases in which he used silver wire to close the abdomen of patients whom he considered potential candidates for disruption. The same technic in the

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* From the Gynecological Service, Harlem Hospital, Henry C. Falk, M.D., Director.

hands of others has not been without mishap. The advocates of the silk technic state that silk is less likely to result in disruption than catgut. The majority of the cases with disruption (275) reported by Sokolov followed the use of silk. Linen offers no guarantee against disruption (Jenkins).

Since there is no legal standard of catgut gauge and strength in the United States, most companies have adopted the Federal specifications* as their standard:

The holding power of the suture is dependent on the tensile strength of the suture and the strength of the tissue in which it is placed. It is only in fascia that the holding power of tissue is greater than the strength of the finest catgut. (Fig. 1.)

Howes and Harvey did experiments on animals to determine these factors. Some of their conclusions were as follows:

* Catgut ligature shall be contained in tubes made of transparent clean glass tubing of good quality and uniformity of wall material. Tubes when sealed, shall measure 95 to 110 millimeters in outside length and from 10 to 12 millimeters in diameter. Each tube shall have engraved at or near its center an encircling fracture mark of proper depth to enable the tube to be broken evenly at the fracture mark without undue twist, introduced in the tube in a manner to allow the top loop of the coil and the fracture mark to facilitate removal of ligature. Each tube shall contain one strand of sterile catgut ligature in the tubing fluid specified.

"Each tube shall contain a sufficient amount of tubing fluid to cover completely the coiled catgut when the tube is held in vertical position.

"This tubing fluid shall be stable under sterilizing tests as described below, non-toxic and anhydrous and shall contain no substance which will have a deleterious effect upon the breaking strength of the ligature, even after the ligature has been stored for an indefinite period. The breaking strength of the catgut shall be determined immediately after autoclaving the tube for thirty (30) minutes at 120°c.

"Each carton containing tubes of boilable catgut ligatures shall be plainly marked with the manufacturer's control (lot) number, in order to identify the lot in the manufacturer's original and permanent record of sterilization, and such records shall be open to government inspection."

This specification has no legal status but it is the specification which is followed by the various agencies of the Federal Government in the purchase of catgut.

The function of a suture is to hold tissue in position until the healing of a wound makes such artificial support unnecessary. When this purpose has been accomplished, the material employed should be absorbed and if not absorbed should be inoffensive.

TABLE 1
FEDERAL STANDARD STOCK CATALOG

Nominal Diameter Inch				Breaking Strength	
Millimeter		Inch		Minimum on a Straight Pull	Pounds over a Reef Knot
Mini- mum	Maxi- mum	Mini- mum	Maxi- mum		
00	0.229	0.305	0.009	.012	4	2.8
0	.305	.381	.012	.015	7	4.9
1	.381	.457	.015	.018	10	7.0
2	.457	.533	.018	.021	13	9.1
3	.533	.609	.021	.024	20	11.2
4	.609	.685	.024	.027	..	14.0

—•—•—•—•— No. 0—20-day chromic catgut
—•—•—•—•— No. 00—20-day chromic catgut
— — — — — — No. 3—20-day or 40-day chromic catgut
——————— No. 2—plain
—o—o—o—o— Tensile strength of wound

Fig. 1. Relation of decreasing tensile strength of catgut to increasing tensile strength of wound. (Modification of graph by Howes and Harvey.)

1. There is a "lag period" of between four and five days, when the strength of a wound is merely that of the fibrinous adhesions on the surface of the wound. The tensile strength of a wound which is a measure of the proliferation of the fibroblasts begins to rise abruptly at the end of this time and approaches the maximum strength of a wound in ten to twelve days.

2. The relation of the decreasing tensile strength of catgut to the increasing tensile strength of the wound is shown in Figure 1.

3. Catgut, being a foreign body, even in small amounts, causes some degree of reaction in the tissue in which it is embedded. It possesses an advantage over nonabsorbable sutures in that it is capable

of digestion and by this process ultimately disappears.

4. When infection is present or occurs during the healing of a wound, the digestive process is intensified so that the gut, irrespective of the degree of chromatization, rapidly disappears, with an early loss of healing power. Under the same circumstances the nonabsorbable suture acts as a persistent nidus of infection which eventually leads to its extrusion.

5. The chromic catgut of one manufacturer showed complete loss of tensile strength within six days, regardless of size or whether it was of the twenty or forty-day variety, emphasizing the importance of knowing the material being used.

6. Foreign bodies and flaws in many brands of catgut are found apparently due to splicing of the catgut and to bending of brittle "boilable" catgut in narrow glass tubes (Kraissl). These imperfections appreciably alter the rapidity of loss of tensile strength.

Harvey and Howes have shown that the tissue reaction is in proportion to the amount of catgut used. Therefore, the least amount of gut necessary to hold the approximation of the tissues until the wound gets sufficient strength to take over should be used. A comparison of the velocity curve* of the healing wound and the curve of the disappearance of catgut embedded in tissue, shows No. o twenty-day chromic catgut satisfies all requirements of the stitch in fascial and connective tissue layers. Even finer gut than this is sufficient for those structures in which the holding power of the stitch is less.

Bowen* also states that the use of finer grades of catgut is advantageous, although nonabsorbable sutures in selected cases are advised.

Wolff and Priestly in their investigation of the absorption of catgut in the human found this: (a) Contrary to the general belief, drainage and suppuratory wounds do not cause early absorption of catgut. (b) Individual variations in the absorption

* Am. J. Surg., 47: 3, 1940.

time of catgut occur normally. (c) Certain brands of catgut consistently last longer than other brands. (d) Small sizes of catgut last as long or longer than large sizes. Single strands of catgut last as long as double strands. (e) Labels indicating the length of time necessary for absorption of catgut are entirely fallacious insofar as the human being is concerned.

Improper Closure of Peritoneum. Freeman in pioneer experimental work, demonstrated that faulty technic can adequately produce evisceration in the absence of other factors. An omental plug is wedged into a gap of the suture line of the peritoneum and gradually works its way out. Thus a rupture occurs from within outward. Since peritoneum seals over within a few hours, the process of evisceration must begin soon after operation. This leads one to believe that a careful closure of the peritoneum prevents evisceration, although Jenkins believes that omentum is more protective than causative.

A variety of factors resulting in improper peritoneal closure and escape of the omentum plug have been suggested: (1) Infection, (2) improper hemostasis, (3) interposition of fat, (4) improper apposition of tissue planes, (5) tissue necrosis due to rough operation and mass ligation, (6) peritoneal sutures too unduly spaced, and (7) multiple perforations of the peritoneum due to improper relaxation, improper placement of sutures, etc.

Type of Incision. Many authors have suggested various types of incisions to avoid fascial and muscular strain on the healing wound, (Singleton and Blocker). However, eviscerations have occurred in every type of incision including McBurney,* although Boland states that lower abdominal incisions, particularly those in the midline are extremely susceptible to disruption.

Drainage. According to Colp, the incidence of disruption in drained cases is 1.22 per cent as compared to .84 per cent

* Maes, Boyce and McEstridge. Am. Surg., 100: 968, 1934.

in undrained cases. Drainage often implies suppuration and, particularly if a continuous suture is used, early dissolution of the catgut may result in evisceration. Therefore, a separate stab incision or, if this is not feasible, interrupted sutures are advised. The presence of a drain enhances bacterial spread from the skin into the wound (Jenkins). In the emergency service at the Knickerbocker Hospital in New York City, it was the practice with bad appendices to suture only the peritoneum and posterior sheath. These patients healed very well and none eviscerated, although it has been repeatedly stated that infection hastens the rate of digestion of catgut sutures.

Mechanical Damage. The injury to a continuous catgut suture in the anterior sheath by the cutting action of a tightly made tension suture has been mentioned. The tightening up of a continuous suture with a needle holder or hemostat results in local damage to the catgut which not only weakens its tensile strength, but also renders the catgut more vulnerable to the digestive action of the tissue at the point of local damage.

Improper handling of boilable catgut by the operating room nurse alters its tensile strength. When this type of catgut is removed from the tube it is very brittle and nonpliable.

If catgut is extended without "wetting" there is likely to be some degree of fracturing at the point where it has been previously bent. On the other hand immersion into very hot water results in a marked decrease of tensile strength.

DISTURBANCES

It has been a common observation that elderly patients suffering from chronic sepsis, cachexia, malnutrition, vitamin deficiencies and particularly carcinoma are particularly prone to wound disruption (Colp, Jenkins, Grace, Whipple and Elliott). The knowledge of the biological and nutritional factors involved in wound healing is scanty, although it seems obvious

that the above mentioned factors must play some significant rôle.

E. Von Graff reports four successive cases in which sugar tolerance tests revealed a diabetic condition. Greenhill was able to induce normal healing in a diabetic patient with an unhealed wound by the use of insulin. Contrary to their beliefs, Bettman and Lichtenstein found only six cases of cancer in thirty-two eviscerations. Boland observed that the incidence of evisceration in colored patients who were poorly nourished and often luetic was extremely low.

ALLERGY

J. Kraissl et al. have done interesting work concerning the relation of catgut sensitivity to a wound. They present evidence that sensitivity of the individual to one or more of the specific constituents of the suture material may be a cause of its premature absorption. In eleven animals sensitized to plain catgut, three disrupted their abdominal wound, two showed definite abnormal wound healing, while six healed normally. In the group of eight sensitized to chromic acid, three disrupted, three showed abnormal healing and two healed normally. These results are in marked contrast to the control animals in whom no disruptions and only one abnormal healing occurred. In a clinical study of thirty cases of wound disruption the following was found: (a) Catgut practically gone, chromic catgut disappeared; (b) of five patients who disrupted and who had a history of allergy, all showed evidence of sensitivity, while 52 per cent of those who gave no history of allergy gave immunological evidence of allergy.

Grotia and Gilson and Tripp have reported cases of disruption in whom allergic response to catgut seems to be the primary factor. Frugoni, however, has attempted to disprove this theory.

L. S. Fallis has called attention to the marked seasonal incidence of dehiscence, this complication apparently occurring in

the winter and summer months. The clinical picture in the non-infected cases suggests a possible allergic reaction in his opinion.

In a series of 1,543 consecutive laparotomies on the gynecological service of Harlem Hospital, New York City, during a three-year period* there were five cases of postoperative evisceration.

Sex. These cases occurred on the gynecological service.

Age. The age varied from twenty-three to forty-five years. These cases occurred in the third decade of life. The average age was 34.6 years.

Age in Years	Number of Cases
23	1
31	1
36	1
38	1
45	1

Incidence. The incidence of disruption in this series was 0.3 per cent. The incidence compares favorably with those of various writers.

	Per Cent
Boland	0.28
Sokolov	2–3 (European statistics)
Bettman and Lichenstein	0.4
Koster and Kassman	0.22
L. S. Fallis	0.6
Compilation by Bowen	0.49

Incision. The incision in all the cases was a lower abdominal, left paramedian incision.

TABLE I

Case No.	Disease	No.
1	Ruptured ectopic	1
2	Uterine fibromyomas and fibromyoma with twisted pedicle	1
3	Exploratory laparotomy (uterine pregnancy—error in diagnosis)	1
4	Fibroid uterus, chronic salpingitis, hemorrhagic cyst of right ovary	1
5	Fibromyoma of uteri and intraligamentary fibroid	1

* The last three years have been chosen, because the same staff of operators were in charge.

TABLE II
OPERATIVE PROCEDURE AND DAY OF DISRUPTION

Case No.	Procedure	Day of Disruption
1	Right salpingectomy	Third
2	Supracervical hysterectomy	Fifth
3	Appendectomy	Eleventh
4	Supracervical hysterectomy with salpingo-oophorectomy and appendectomy	Ninth
5	Supracervical hysterectomy and removal of intraligamentary fibroid	Fifth

Previous History. One patient had an old stab wound of the abdomen. The other patients gave no history of previous operations, asthma or any form of allergy.

Season. All the cases occurred in the spring of the year.

Anesthesia. Avertin and ether inhalation anesthesia were used in all cases, except Case 1 for whom ether inhalation alone was employed.

Day of Disruption. These cases were prepared very carefully for operation and were in the hospital from ten to twenty-one days before operation. Case 1 was an exception, due to her condition of emergency as a ruptured ectopic.

LABORATORY DATA

Case No	Age	R.B.C	W.B.C.	Hg. Per Cent	Sed. Time	Bl. Sugar
1	31	2,910,000	24,000	55		
2	38	3,400,000	12,000	65	Normal	88
3	23	3,500,000	10,200	65	Normal	80
4	36	3,700,000	8,600	70	Normal	90
5	45	3,500,000	9,200	60	Normal	78

Case No.	Creat.	Urena N.	Urine	Kahn	Bl. Press.	Kidney Function
1	. .	.	Neg.*	Neg.	56/40	
2	1.1	9.2	Alb.	Neg.	118/80	Good
3	1.2	15	Neg.	Neg.	104/–4	Good
4	1.4	16	Neg.	Neg.	100/65	Good
5	1.1	8 2	Neg.	†	165/115‡	Good

* Emergency. Complete work-up could not be done.
† In testing kidney function, the Mosenthal, P.S.P. tests and blood nitrogen were done.
‡ This was on admission and came down to within normal limits before operation.

Any anemia was corrected before operation.

In these cases it is significant to notice the absence of any disturbed carbohydrate metabolism, malignancy or malady of a wasting nature. Although the percentage

of syphilis among our patients is quite high only one disrupted case was luetic.

Closure of Abdomen. The abdominal wound was closed in layers with continuous plain catgut No. 2 suture for the peritoneum, continuous chromic catgut No. 2 suture for the fascia, four retention sutures (nonabsorbable) placed on two rubber bolsters, one on each side of incision and the skin closed with michel clips. In Cases No. 3 and No. 4 the peritoneum was sutured with separate double sutures of fine chromic catgut No. o-o.

Clinical Course. The average time of disruption was the sixth day. Case No. 2 disrupted on the third day and showed no postoperative abdominal distention. On the second day, her dressings were soaked with an ammoniacal smelling fluid. On the third day postoperatively the wound was found gaping apart and a wad of ommentum protruding from the upper angle of the wound. Upon seeing this, one cannot but think of Freeman's theory. In Case No. 2, that disrupted on the fifth day, a blood-stained fluid was noticed on the dressing on the third day postoperatively. This wound was inspected at this early date because of the severe pain of which the patient complained. Proper interpretation of this serosanguineous discharge would have made the diagnosis at this time. In Case No. 3, sneezing, coughing, vomiting and marked abdominal distention occurred. Gastric lavage was employed. On the sixth postoperative day the patient began to improve. At the time of disruption, the patient was apparently comfortable. This case disrupted at the latest date in this series, the eleventh day. In Case No. 4, evisceration occurred on the ninth day. Postoperative convalescence was uneventful, except for the complaint of pain in the site of the incision since the second postoperative day.

In case No. 5, which disrupted on the fifth day, the patient began to cough on the first postoperative day. The diagnosis of a postoperative pneumonia was considered. The patient was treated accord-

ingly and began to improve. The abdomen remained soft. On the fifth day, the skin clips were removed. After supper that day, the patient vomited twice. One and one-half hours later she went into shock. Examination of the wound at this time, showed an evisceration. Whether the vomiting was due to the disruption or caused the disruption is speculative.

The most frequent symptom presented by these cases, was pain at the site of the abdominal incision. In one case, the patient felt "something give way" which subsequent observation of the wound confirmed. In four cases the presence of wound evisceration was first noticed when the dressings were changed and the wound inspected. In two cases, the presence of serosanguineous drainage on the dressings was the first suggestion of disruption. In two cases, the wound disruption occurred shortly after the removal of the tension sutures.

Abdominal tension was absent or negligible in four cases. The one case with abdominal distention eviscerated on the eleventh day, the latest date in this series, and then after the abdominal distention subsided.

Allergy. In all cases skin tests for catgut allergy were negative.

Operative Findings. At the time of disruption, none of the wounds showed any obvious signs of infection. In Case No. 2, careful inspection of the wound revealed the knot of catgut at the upper angle of the peritoneum and the knot of catgut at the middle of the wound. The lower half of the peritoneum which had been sewed with a separate strand of catgut was intact. In Case No. 3, the wound was clean and no catgut was seen. The upper half of the peritoneal wound was open and through it was protruding a loop of small intestine. The lower half of the peritoneum was well healed. In Case No. 4, the entire wound was disrupted and the intestines pushed out. The wound was clean, that is, no visible suppuration was present. No sign of the catgut sutures was

present. In Case No. 5, the middle portion of the wound was found gaping and the skin clips in this region open. Upon removing the remaining skin clips a wad of omentum, about 2 cm. square, was found protruding from the upper angle of the wound. Upon raising this omentum, several loops of small intestines were found occupying the entire area of the incision. The wound was apparently clean.

It is interesting to note that in this series of cases, all the eviscerations started in the upper half of the peritoneal wound.

In brief, an examination of the disrupted wound showed no gross infection, a total absence of catgut and apparent deficiency in peritoneal healing.

Diagnosis. Pink staining observed on the dressing of the wound, in greater or lesser amount, is the earliest and most characteristic sign of wound disruption. It has been observed as soaking through the overlying dressings into the covering sheets. The discharge which is peritoneal fluid should not be disregarded if an early diagnosis of disruption is to be made. Pain is the next most important symptom, especially if it is referred to the wound after a fit of violent coughing or vomiting. In the presence of either of these symptoms the wound should be carefully observed for wound disruption. If the skin is apparently healed, it may be opened for inspection. Although sudden shock or symptoms of intestinal obstruction have been said to occur, they were not observed in this series.

DISCUSSION

Freeman's theory of inaccurate closure of the peritoneum seems most plausible as the primary factor in this series of patients. It is well known that the peritoneum seals over in a few hours and is remarkably elastic tissue. It would seem that any suture material capable of holding the peritoneum together during this brief period would be sufficient to prevent evisceration, although it might not be sufficiently strong to prevent postoperative

herniation. Suggestive findings were those of Cases 2, 3, 4 and 5.

The question of faulty sutures was considered immediately after the first evisceration. The entire stock of catgut sutures was replaced with a fresh supply. Following the occurrence of the third evisceration, the plain catgut suture for the peritoneum was changed to a double suture of No. 0-0 chromic catgut. However, two disruptions occurred following the change of technic. The technic employed was otherwise unchanged.

Even though there was no visible suppuration present in any wound, the possibility of a low grade or nonpurulent infection cannot be excluded.

The factor influencing disruptions seem largely attributable to the surgeon and his technic. Improper closure of the peritoneum with widely spaced sutures allows the immediate protrusion of a piece of omentum or gut through the peritoneum. Serum is thrown out by the ensnared omentum or gut which causes rapid digestion of the catgut and retards the fibroplasia in the healing wound. This is a direct cause of evisceration.

Knots, poorly tied, may unravel immediately after laparotomy, before the peritoneum has had a chance to seal over. The omentum or gut is pushed through, with a resulting beginning evisceration. When sutures are equally spaced on either side of the peritoneal incision, the peritoneum under a sudden strain may tear as a stamp tears along its perforations. The use of bulky catgut in suturing the peritoneum leaves a weakness at the needle puncture, which may tear when a sudden strain is exerted on the wound. Bulky suture material causes more severe tissue reaction with a resultant edema, which interferes with the mechanical healing of the peritoneum. The grasping of the peritoneum with large clamps causes a devitalized area at the site of clamping. A suture passed through such areas will tear out very rapidly, leaving a nidus for eviscer-

ation. It is preferable to use allis clamps which materially reduce this danger.

When a patient has a secondary suture of a disrupted wound and recovers, there seems to be no further interference with wound healing. This is quite remarkable, considering the fact that through-and-through sutures are usually used, which must result in less accurate approximation of tissue than the layer-to-layer method. There seems to be two probable explanations: (a) That the engorged, thickened omentum lying immediately beneath the peritoneum, acts as a shield; and (b) That the process of wound healing, the so-called "lag period" has been prolonged. However, by the time the secondary suture is done, this "lag period" is in its final stage and the process of healing continues uninterruptedly.

If the peritoneum is properly sewn, the catgut suture, unless it is fractured or abused, will have sufficient tensile strength to hold the peritoneum together during the short period of time necessary to seal it. It would seem that too much catgut, bulky or faulty, poor hemostasis and improper handling of the wound, would cause retarded wound healing. Under these circumstances increased intra-abdominal pressure and strain on the wound may result in postoperative herniation instead of evisceration.

The great majority of wound eviscerations even in patients whose pathological status is reported as conducive to this catastrophe, can be prevented by thorough application of the knowledge of wound healing. The careful and accurate approximation of the peritoneum which is paramount in the prevention of postoperative disruptions, entails the following: (1) The use of fine, round needles; (2) No. oo plain or chromic catgut; (3) proper placement of stitches; (4) allis clamps to hold peritoneum in preference to heavy crushing clamps, and (5) application of tight abdominal binder, before patient leaves operating room.

SUMMARY

1. A résumé of literature shows that the cause of wound disruptions may be classified under the following headings: (a) Increased intra-abdominal tension; (b) faulty technic; (c) metabolic disturbances, and (d) allergy.

2. In the five cases reported, infection, allergy and metabolic conditions did not play a rôle of postoperative wound disruption.

3. Increased intra-abdominal pressure did not appear to be a primary factor.

4. In all cases, there was a defect in the healing of the peritoneum. This defect in the peritoneum was probably due to faulty technic as previously described.

5. The type of suture material did not effect the rate of postoperative wound disruption.

6. Close observance of the principles of careful and proper peritoneal closure should lower the incidence of postoperative wound evisceration.

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Usually after a period of months or years the thyroid enlargement of simple colloid goiter disappears with medical treatment, or perchance with no treatment at all. In some cases the enlargement continues throughout adolescence, increasing in size in young womanhood, and finally reaching the bosselated state in midlife.

The brief excerpts in this issue have been taken from "Diseases of the Thyroid Gland. Presenting the Experience of More Than Forty Years" by Arthur E. Hertzler (Paul B. Hoeber, Inc.).

ULTRAVIOLET IRRADIATION OF AUTOTRANSFUSED BLOOD IN THE TREATMENT OF PUERPERAL SEPSIS

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AFTER seven years of clinical research, several physicians in various parts of the United States compiled clinical evidence on a treatment for pyogenic infections that, to date, has not been widely published. These men co-operated and exhibited their findings in the scientific exhibits' section of the American Medical Association Convention held in New York in June, 1940. The exhibit dealt with the treatment of pyogenic infections by the irradiation of autotransfused blood with ultraviolet rays, known as hemo-irradiation therapy.

This paper will deal only with the treatment of puerperal sepsis by that method, giving a description of the procedure and rationale as well as brief comment on other therapeutic measures used and clinical responses noted. The thirteen charts and histories here cited formed a part of the New York exhibit; they represent the total number of cases of puerperal sepsis treated at the Shadyside Hospital, Pittsburgh, Pa. from July, 1937, through May, 1940. Two of these patients were delivered at home and brought into the hospital later. From June 1, 1937, to May 31, 1940, we had 2,486 obstetrical patients delivered. It is significant that since the establishment in July, 1937, of hemo-irradiation therapy, and for the period of time covered by this paper, no deaths have occurred in our institution from puerperal sepsis, one case recovering promptly with sulfanilamide therapy alone.

In April of 1937, we had in our service the second fatal case within a year of beta-hemolytic streptococcus blood stream infection. This case ended fatally, despite intensive therapy with prontisil and pron-

tylin both early and late in the course of the disease. This experience aroused our interest in an article published in the 1934 June issue of North West Medicine, by Virgil K. Hancock, M.D., and E. K. Knott, entitled "Irradiated Blood Transfusions in the Treatment of Infections." Their work on all types of conditions resulted in the belief that in the treatment of pyogenic infections they had, in the irradiation of the blood with ultraviolet spectral energy, a therapy of more pronounced value than any other method known to date.

We started at Shadyside Hospital on cases indicated for treatment by the Knott technic. The results we obtained were gratifying. Our experience with this form of therapy has been wide enough to indicate its usefulness as a valuable adjunct to the treatment of various pathologies.

The procedure is as described by Hancock and Knott, and consists of a treated autotransfusion. Briefly, the patient's own blood is withdrawn from a vein, citrated and returned by gravity to the same vein. As it flows back, the blood passes through a specially designed chamber (capacity 10 cm.) with a quartz window and is exposed to ultraviolet rays which are generated by a water-cooled mercury vapor quartz burner. The average time for 10 cm. to traverse the chamber is nine to ten seconds. The average amount of blood used is $1\frac{1}{2}$ cm. per pound of body weight. The time of exposure, the quantity of blood irradiated and the frequency of treatment are determined by the pathology and the patient's condition.

The general potentialities of ultraviolet rays have long been recognized by scientists in the biochemical fields of research. These

potentialities have been discussed in certain basic texts and monographs; to give only a partial list, Bragg,[1] Clark,[2] Ellis and Wells,[4] Krusen,[5] Laurens,[6] Mayer,[9] Rahn,[11] Schneider, Herman and Sperti[13] and Steel.[14]

The rationale of hemo-irradiation is based on the following accepted facts on the biochemical action of ultraviolet rays. A listing of all the data that contribute to the rationale of this procedure is prohibited by space. It is desirable, however, to list a few of the factors that influenced the application of ultraviolet rays directly to the blood stream: (1) Activation of sterols into vitamin D;[3a] (2) inactivation of toxins and viruses;[3b,8] (3) increased cell permeability;[3c,d] (4) destruction and inactivation of bacteria;[4,15] (5) absorption of ultraviolet by the blood and emanation of secondary radiations;[7] (6) increased oxygen combining power of the blood;[10] (7) presence of measurable amounts of ultraviolet in normal blood, and the deficiency of such in toxic and septic cases, malignancy and the

We have given approximately 3,000 blood irradiations and have not had any detrimental reactions, but have observed clinical manifestations of the foregoing references. In about 4,000 blood counts taken on treated patients there have been no signs of destructive action on either white or red cells. The tendency of blood irradiation seems to be to raise the red cell count and hemoglobin. An increase of 1,200,000 in red count has been observed overnight. If the count is not increased, it is noticeable that it has been maintained, even through severe infections, including hemolytic streptococcus in the blood stream. The white cell count tends to balance; i.e., the high counts decrease and the low counts increase. In most all instances treatment was followed by a sharp reduction in temperature. If septic temperature continued, the charts show a decrease by lysis. The extreme toxic conditions found in many patients were generally relieved after irradiation, and clinical improvement noted. The need for blood transfusions was definitely reduced.

In the cases of puerperal sepsis being presented, the charts and histories show that blood irradiation therapy was not instituted in some instances until other treatment was not accomplishing desired results. In six cases sulfanilamide was administered but was discontinued in favor of hemo-irradiation. Five patients received transfusions of donor blood. Three of the patients receiving sulfanilamide are counted as receiving donor transfusions. Six patients of the thirteen had only hemo-irradiation therapy.

CASE REPORTS

CASE I. No. 76081, Mrs. M., age forty-one, a negro, was admitted on November 21, 1938 and discharged on December 23, 1938. This patient was referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis).

The patient, para II, was admitted November 21, 1938 for delivery. Temperature, pulse, and respirations were normal. Routine urinalysis was negative. On November 23, red cell count was 3,980,000, hemoglobin 70 per cent, white cells 10,100—90 per cent neutrophiles. Because of secession of labor pains by this time plus the onset of fever to 102.4°F, consultation was held and a Porro cesarean section performed because of a fibromyoma present in the cervical region. The diagnosis from the tissue examination showed acute septic endometritis and metritis. Sulfanilamide was started immediately and continued for four days or until November 28, inclusive, in doses of 100 gr. the first day and 60 gr. for the next three days. Despite this therapy her temperature reached 104.8°F. by November 28. The sulfanilamide therapy was stopped, and blood irradiation therapy instituted.

Her temperature gradually receded until December 4, with marked improvement in her general condition. There was a gradual rise in temperature during the next two days, reaching a peak of 101.4°F. on December 6. At this time another blood irradiation treatment was given. From this point on she made an uneventful convalescence, being discharged from the hospital on December 23, 1938 in apparently good condition.

CASE II. No. 70154, Mrs. Z., age twenty-seven, white, was admitted on November 19,

1937 and discharged on December 18, 1937. She had been referred by Dr. W. G. Thompson. The diagnosis was puerperal sepsis (acute septic endometritis and parametritis).

tient had a chill and the temperature reached 105°F. A soft, tender, non-involuting uterus was present with marked tenderness on pressure over both lower quadrants. The lochia was very
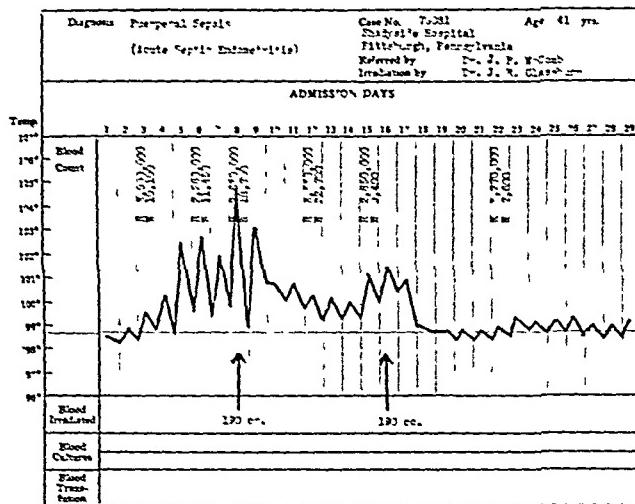
FIG. 1. Case I. No. 76081—Temperature graph.
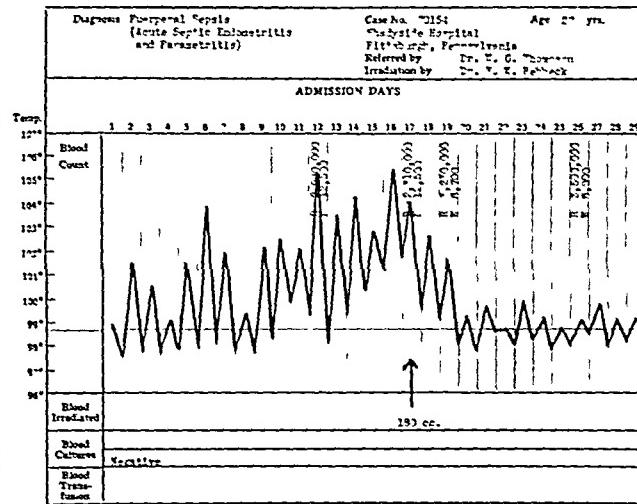
FIG. 2. Case II. No. 70154—Temperature graph.
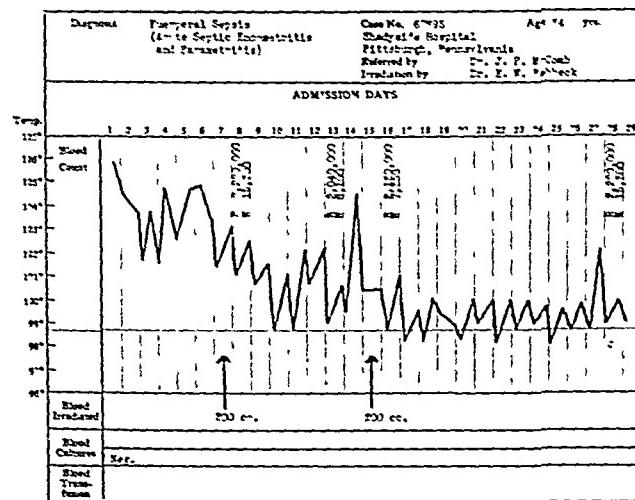
FIG. 3. Case III. No. 67895—Temperature graph.
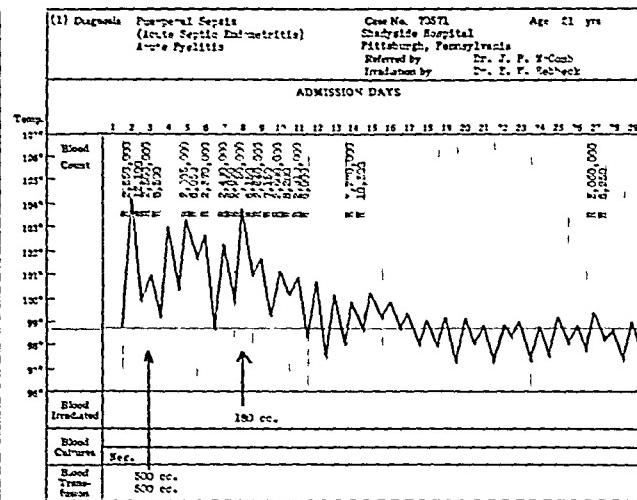
FIG. 4. Case IV. No. 70571—Temperature graph.

The patient, para 1, admitted as pre-eclamptic, blood pressure 165/70, albuminuria, with daily injections of magnesium sulfate and 5 per cent glucose and saline (November 19 to November 25). A tube was inserted into the uterus to induce labor on November 20. She was delivered on November 26, of a persistent occiput posterior; November 23 she showed marked pyuria. This increased until November 28; but was negative on the twenty-ninth, thirtieth, and first. Pyuria reports on December 2, 3, 4, 5, 6, 7, 9, 10, 13, 14, 15, 17, and 18. Temperature was 102°F. November 28; on November 29 temperature was 102.2°F. On November 30 the patient complained of pain in the left lower portion of the abdomen; temperature reached 102°F. On December 1 the pa-

offensive. A diagnosis of acute septic endometritis and parametritis was made. Blood cultures taken December 1 and December 5 were negative. This temperature varied from 105 to 101°F. with daily chills until December 6. On the same day blood irradiation therapy was instituted. Her condition was somewhat improved on December 7 and was markedly improved by December 8. This improvement continued uneventfully, and the patient was discharged from the hospital in good condition on December 18, 1937, twelve days after blood irradiation. She was in good health six months later.

CASE III. No. 67895, Mrs. C., age thirty-four, white, was admitted on July 3, 1937 and discharged on July 31, 1937. She had

been referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis and parametritis).
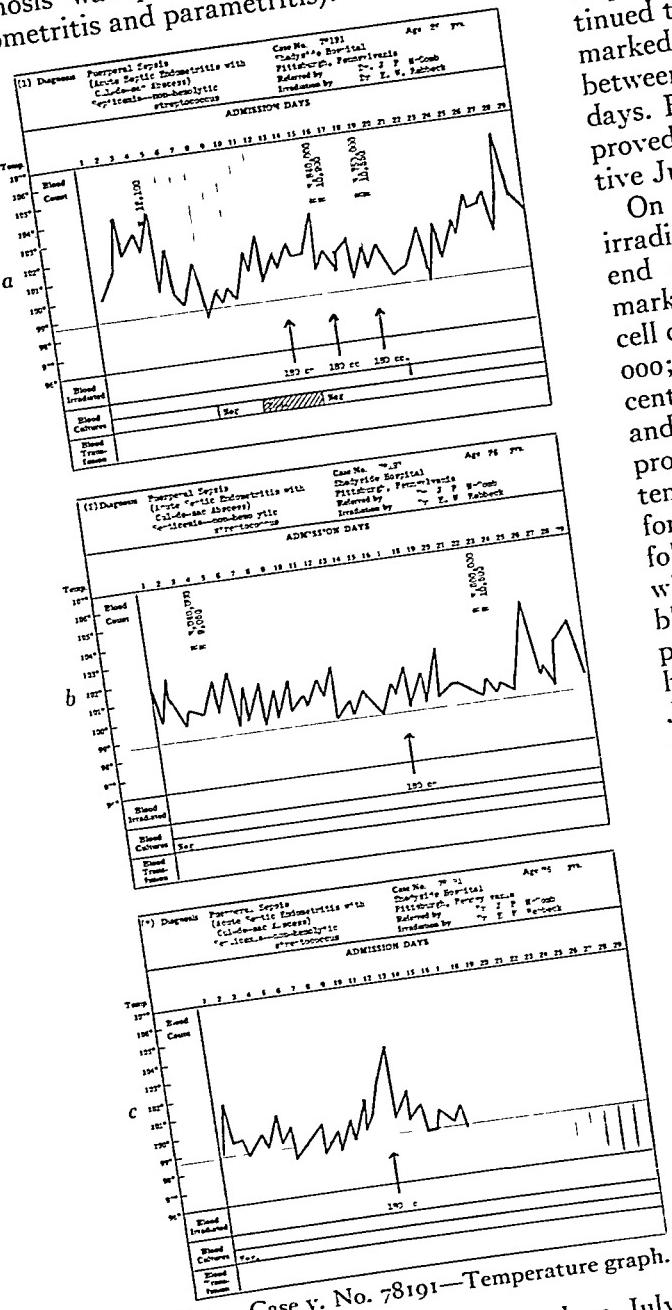
FIG. 5. Case v. No. 78191—Temperature graph.

The patient, para VII, admitted on July 3, complained of fever, burning pelvic pain, and gave a history of delivery June 30, (four days previous) Soon after delivery the patient noticed marked pain and tenderness throughout pelvis and lower portion of the abdomen, and in view of the foul smelling lochia with blood clots noted in the physical examination a diagnosis was made of an acute

suppurative endometritis and parametritis. On the day of admission Dakinization of the uterus was done. Cervical culture showed staphylococcus. However, the patient continued to run a high septic clinical course with marked toxemia, her temperature ranging between 101.4 and 105°F. for a period of six days. Blood cultures taken July 3 and July 8 proved negative. Routine urinalysis was negative July 6.

On the seventh day of hospitalization blood irradiation therapy was instituted, and at the end of thirty-six hours the patient seemed markedly improved. The next few days her red cell count varied between 2,040,000 and 2,540,-000; her hemoglobin between 45 and 75 per cent; and her white cell count between 8,450 and 15,300. Despite her apparent clinical improvement the patient continued to run a temperature varying between 98.4 and 103.4°F. for the next six days, and on the seventh day following irradiation therapy reached 104.6°F. with chills at this time July 16. On July 17, blood irradiation therapy was repeated. The patient improved markedly in twenty-four hours and except for a rise to 102.2°F. on July 29, 1937 convalesced uneventfully and was discharged July 31, 1937.

CASE IV. No. 70571, Mrs. H., age twenty-one, white, was admitted on December 16, 1937 and discharged on January 17, 1938. She had been referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis acute pyelitis).

This patient, para II, was admitted December 16, for cesarean section because of a history of an extremely difficult labor fourteen months previously. Temperature, pulse and respirations were normal on admission. Following cesarean section the day of admission the patient began to have chills and run a septic temperature ranging between 100 and 103.2°F. On December 17 x-ray examination of the chest was negative. A persistent pyuria with right-sided kidney distress later accompanied by left-sided kidney distress persisted with chills for the next week; likewise, an aching, tender sensation in the uterus continued present for about a week. Blood counts were as listed above. The lochia never became offensive. The patient became extremely septic. Blood cultures taken December 17 and December 23 were negative. A diagnosis of acute pyelitis, bilateral, and acute septic endometritis was made

by her attending physician and consultants. A transfusion was given of 1,000 cm. of blood on December 18.

On December 24 with a temperature reaching 103.4°F., pulse 120 to 130, respirations 28 to 32, blood irradiation therapy was instituted. There was a slight rise of temperature to 103.8°F. The patient at this time was quite toxic and considered in a desperate condition. Her subsequent course as shown by the temperature graph was steady improvement until she was discharged on January 17, 1938, the thirty-fourth postpartum day, in good condition. She has remained in good health since her discharge.

CASE V. No. 78191, Mrs. S., age twenty-six, white, was admitted on April 8, 1939 and discharged on July 2, 1939. She had been referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis with cul-de-sac abscess: septicemia—non-hemolytic streptococcus).

Mrs. S. was aged twenty-six, para 1, had a normal delivery April 9. Within twenty-four hours she developed chills with excursion of temperature to 104°F. degrees, pulse 130, respirations 22. Culture from the cervix at this time showed non-hemolytic streptococcus. A diagnosis of acute septic endometritis was made because of a tender, slow involuting uterus with offensive lochia; likewise, a diagnosis of dementia praecox was made by the neurological department. Blood cultures taken on April 10 and April 12 were negative. The blood cultures taken April 19, April 20, and April 22 were positive for non-hemolytic streptococcus gamma type. She received sulfanilamide therapy, averaging 60 to 120 gr. daily from April 10, to April 20. Blood irradiation treatments were given April 21, April 27, and May 24. Subsequent blood cultures on April 23, April 25, April 26, April 27, April 29, May 1, May 3, May 4, May 9, May 15, May 18 were all negative. On the twenty-eighth postpartum day, abscesses in the right vaginal wall near the introitus and the cul-de-sac were incised. Contaminating organisms only showed on culture. On the thirty-third postpartum day, an abscess appeared over the left scapular region; this was incised and pus, culturing non-hemolytic gamma streptococcus, was obtained. There was a tendency to further excursion of temperature on the forty-fifth postpartum day, and another blood irradiation treatment was given at this time. Her subsequent progress has been un-

eventful surgically. This case was complicated by dementia praecox of the manic type. She was discharged from the hospital on August 2, 1939 in good condition, having been treated for her mental condition by "shock" therapy upon recovery from the obstetrical complication, June 4, 1939. The patient was last seen in October, 1940, at which time she seemed in good health and, while still under treatment by the neurological department for dementia praecox, was considered as making excellent progress from the latter illness.

CASE VI. No. 83568, Mrs. M., age twenty-three, white, was admitted on March 8, 1940 and discharged on March 25, 1940. She had been referred by Dr. J. R. Glassburn. The diagnosis was puerperal sepsis (acute septic endometritis).

The patient, para 1, was admitted in labor March 8, and was delivered a few hours later on the same day. Low forceps were used and an episiotomy was done. The patient left the delivery room in apparently good condition. Her first four postpartum days were uneventful, but on the fifth postpartum day, March 13, 1940 the patient had a large emesis and complained of pain in the lower portion of the abdomen followed by a chill with a rise in temperature to 103.2°F. Her offensive lochia cultured indifferent streptococcus. Blood cultures taken March 14, 15, 16, 17, 18, 19, and 22 were all negative. The following day her temperature rose to 105°F.; general toxic symptoms developed. Blood irradiation therapy was instituted.

The following day the patient's temperature rose to 105.2°F. Forty-two hours after blood irradiation her temperature fell to 100°F.; her blood count taken the previous day proved to be 2,870,000—red blood cells, 10.2 Gm.—hemoglobin. A 500 cm. transfusion was given. The patient throughout this day appeared markedly improved in every respect. On the seventeenth she showed a rise in temperature to 102.8°F. which fell the following morning to 99. From this point on the patient convalesced uneventfully and was discharged March 25 in apparently good health.

CASE VII. No. 73574, Mrs. B., age twenty, a negro, was admitted on June 28, 1938 and discharged on July 10, 1938. She had been referred by Dr. P. D. Bier. The diagnosis was puerperal sepsis (acute septic endometritis).

This patient; para IV, was admitted June 28, with normal temperature, pulse and respira-

tions. She was delivered on June 30, with a left occipito-anterior presentation. Routine urinalysis was negative June 28. On July 2,

was generally unimproved with her temperature rising to 103.4°F. Blood culture taken on this day was negative. However, her tempera-
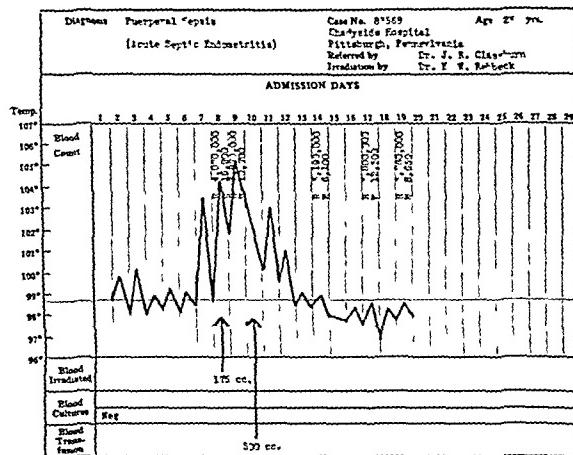
FIG. 6. Case vi. No. 83568—Temperature graph.
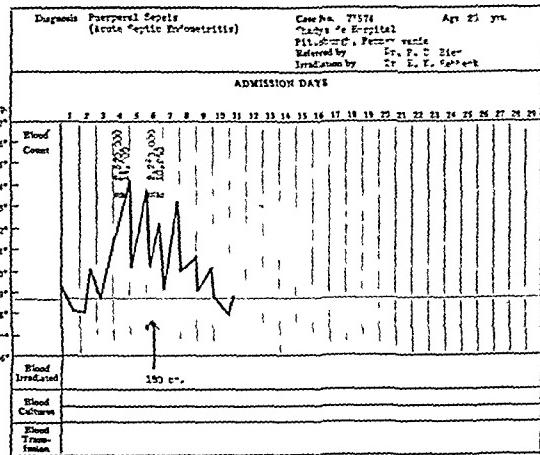
FIG. 7. Case vii. No. 73574—Temperature graph.
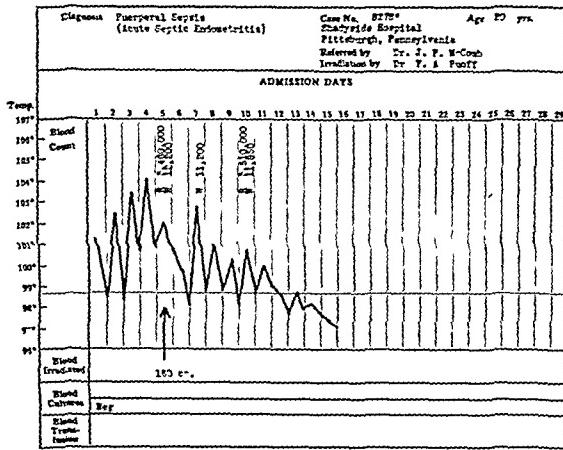
FIG. 8. Case viii. No. 82783—Temperature graph.

FIG. 9. Case ix. No. 82879—Temperature graph.

the patient had a large piece of placental tissue removed, followed by a discharge of sanguineous, offensive smelling lochia The uterus was tender to palpation. A diagnosis of acute septic endometritis was made. Following this her temperature rose to 102.8°F. The following day her temperature rose to 104°F.; this was accompanied by frequent chills and a weak, thready pulse. Blood culture taken at this time, July 3, was positive for Staphylococcus albus, probably contamination. Blood culture taken July 6, was negative. Routine blood count revealed a red count of 2,570,000 hemoglobin 55 per cent, and white cell count 14,200.

The temperature rise and chills persisted on the following day, July 4, and on July 5 blood irradiation therapy was instituted. The day following irradiation, July 6, the patient

ture began to fall on July 7, and the condition improved markedly. She progressed rapidly and uneventfully for the next three days leaving the hospital July 10, 1938 in good condition, five days after her one blood irradiation.

Case viii. No. 82783, Mrs. M., age twenty, white, was admitted on January 21, 1940 and discharged on February 4, 1940. She had been referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis).

The patient, para ii, was admitted on January 21, in labor and was delivered the same day. Delivery was normal. During the second stage lacerations occurred which were repaired. Temperature, pulse and respirations were normal on admission. The same day following delivery her temperature rose to 101.4°F. This rose the first postpartum day to

102.4°F.; the next day to 103.4°F., on the third day to 104°F. Cervical, vaginal and blood cultures taken on January 24, showed staphylococ-

FIG. 10. Case X. No. 75988—Temperature graph.

cus albus. The uterus was tender to palpation, and a diagnosis of acute septic endometritis was made.

On January 25 blood irradiation therapy was instituted. Her temperature fell the following day to 98°F. Marked improvement in the clinical condition was noted, but forty-eight hours after blood irradiation the temperature rose to 102.8°F. Temperature dropped the following day to 98.8°F. and slowly subsided. The patient improved clinically with subsidence in temperature and convalesced uneventfully until the day she was discharged in apparently good health on February 4, 1940.

CASE IX. No. 82879. Mrs. H., age nineteen, white, was admitted on January 27, 1940 and discharged on February 8, 1940. She had been referred by Dr. J. B. McComb and Dr. W. B. Shepard, Jr. The diagnosis was puerperal sepsis (acute septic endometritis).

This patient, para II, was admitted on January 27. Admission temperature was 99.4°F., pulse 110, respirations 22. After a twenty-four hour trial of labor, and, because of moderate cephalopelvic disproportion, a cesarean section was performed. The patient left the operating table in very poor postoperative condition, and a 500 cm. transfusion was given. For her first postoperative day she continued in poor general condition with pulse ranging from 120 to 140. Blood irradiation therapy was instituted at this time. Her temperature dropped to 100°F. that evening but rose again next day to 103°F. Even with this increase in fever her general condition seemed considerably improved. Despite this improvement and because

of the fever her doctor administered sulfanilamide 90 gr. each day for the next two days followed by sulfapyridine for three more
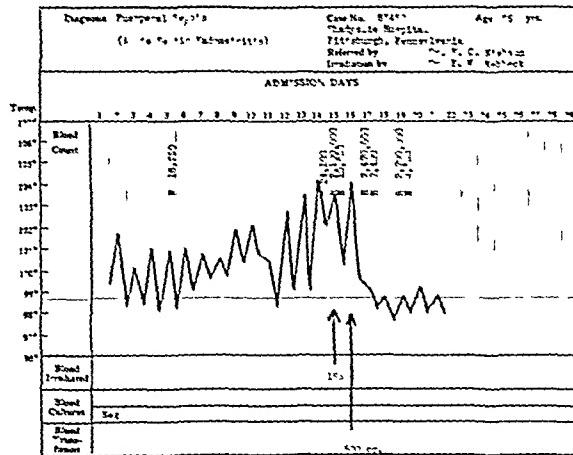
FIG. 11. Case XI. No. 83450—Temperature graph.

days. On the fourth postpartum day her temperature reached a peak of 104°F. The patient was apparently not responding to therapy and becoming more septic. Blood irradiation therapy was again done on this day followed by rather prompt subsidence of fever and improvement in her general condition. She continued to convalesce uneventfully and was discharged as recovered on February 8, 1940.

CASE X. No. 75988, Mrs. K., age twenty-one, a negro, was admitted on November 14, 1938 and discharged on December 6, 1938. She had been referred by Dr. J. P. McComb and Dr. P. D. Bier. The diagnosis was puerperal sepsis (acute septic endometritis with wound infection).

The patient, para III, was admitted at term with a history of previous cesarean section done in 1932. Cesarean section was done again with delivery of a normal infant. Starting on the day of delivery, November 15, and lasting until November 23 a temperature ranging between 100 and 103°F. persisted. There was persistent tenderness in the uterine region with more than normal vaginal bleeding but no offensive lochia. On November 23 blood irradiation was done, and thirty-six hours later her temperature fell to 99.4°F. There was no evidence at the time of irradiation that the wound was infected, but two days later, November 25, purulent drainage began. Temperature in the meantime had receded and the patient's general condition was greatly improved. No blood cultures or blood counts were taken. Two specimens of urine showed no gross abnormalities. The patient's progress was uneventful after the

irradiation. She was discharged in good condition on the twenty-second postpartum day.

CASE XI. No. 83450, Mrs. B., age twenty-
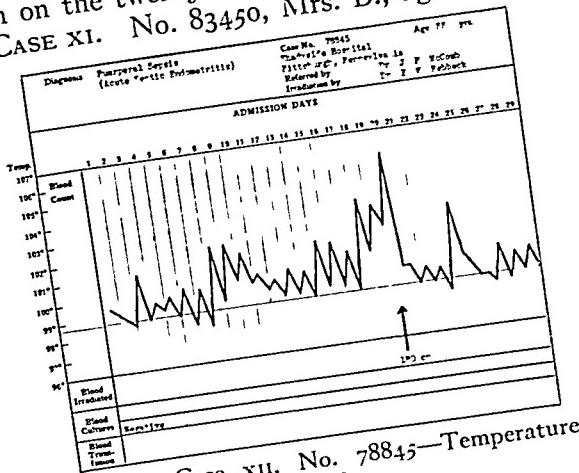
FIG. 12. Case XII. No. 78845—Temperature Graph.

six, white, was admitted on February 29, 1940 and discharged on March 20, 1940. She had been referred by Dr. E. C. Niebaum. The diagnosis was puerperal sepsis (acute septic endometritis).

This patient, para I, was admitted in labor on February 29, and on March 2, was delivered of seven-month old twins; manual removal of the placenta was necessary. Her general condition remained good despite occasional temperature rises from 100 to 102°F. on the first eight postpartum days. Because of fever sulfanilamide averaging from 80 to 120 gr. daily was given from March 8, to March 12, inclusive. However, on March 11 her temperature rose to 102.6°F. following a chill lasting twenty minutes. The uterus was in the pelvis but had been moderately tender for several days. Lochia was serosa but accompanied by many small blood clots, no odor. The breasts were not engorged and there was no kidney tenderness. This temperature continued to rise and on March 12 rose to 103.4°F., on March 13 to 104°F., the white count was 24,000 and the patient became increasingly toxic

On March 14 when her temperature had not fallen below 102°F. for two days, the patient was given blood irradiation therapy. This was followed by a chill. The temperature dropped to 97.6°F., and rose again the following day to 104°F. The day following blood irradiation, March 15, a blood transfusion of 500 cm. was given. Forty-eight hours after blood irradiation the patient's temperature fell to normal ranges; her toxic symptoms had disappeared. Blood cultures taken March 14, 15, 16, 17, and 18

proved to be negative. She convalesced uneventfully and was discharged March 20, 1940.

CASE XII. No. 78845, Mrs. S., age thirty-three, white, was admitted on May 20, 1939 and discharged on June 20, 1939. She had been referred by Dr. J. P. McComb. The diagnosis was puerperal sepsis (acute septic endometritis).

The patient, para I, was delivered of a full term fetus, left occipito-anterior presentation, on May 22, after approximately forty-eight hours of labor, using mid-forceps. During the first week postpartum she ran a septic temperature which gradually increased to a peak of 102.2°F. by the seventh day. Sulfanilamide therapy was instituted beginning with gr. 40 the first dose, followed by gr. 10, four hourly thereafter for five days. Urine examination on the fifth postpartum day showed a moderate number of red cells, many white cells, otherwise not remarkable. Specimen of urine the seventh postpartum day showed moderate red cells, many white cells. Neither of these specimens was catheterized. Catheterized specimen on the fourteenth postpartum day showed occasional red cells and few white cells. The patient presented no complaints. Involution of uterus and vaginal discharge showed a normal course; breasts presented no pathological condition. On the sixth postpartum day a rather severe diarrhea occurred, persistent for forty-eight hours. On the twelfth and thirteenth postpartum days genitalia were quite tender with some edema. Temperature ranged with peaks gradually coming down to 100°F. until the twelfth postpartum day when without other symptoms the fever began to rise, reaching 103.4°F. on the fifteenth postpartum day, at which time a diagnosis of acute septic endometritis was made. Sulfanilamide therapy was discontinued on the twelfth postpartum day.

Blood irradiation therapy was instituted on the seventeenth postpartum day, from which time with exception of one excursion to 102.6°F. on the twenty-first postpartum day convalescence progressed uneventfully. The patient was discharged on the twenty-ninth postpartum day in good condition.

CASE XIII. No. 77357, Mrs. D., age twenty-eight, white, was admitted on February 16, 1939 and discharged on April 23, 1939. She had been referred by Dr. J. P. McComb. The diagnosis was puerperal septis (acute septic endometritis with pneumonic abscesses in cul-de-sac and left pelvic brim; lobar pneumonia).

The patient, para II, was admitted to the Shadyside Hospital on February 16, diagnosis left occipito-anterior presentation at term. She was delivered of both infant and placenta on the same day—a normal delivery. Her admission temperature was 102.8°F., pulse 120, respirations 22. A urinalysis showed occasional white blood cells, no red cells, moderate number epithelial cells, few bacteria; and subsequent examinations included faint traces of albumen, occasional red cells, many white cells, no casts. A septic temperature with peaks of 104.4°F. persisted, and on the fourth postpartum day blood irradiation therapy was instituted. There was a slight improvement in temperature and general condition for the next three days. By the eighth postpartum day temperature again neared the 104°F. mark. Blood irradiation therapy was again instituted. During these days there was considerable abdominal distention with acute dilatation of the stomach, necessitating continuous gastric lavage, and the patient's pulse ranged between 100 and 136. She was moderately toxic. Her blood counts were as shown on the accompanying graphs. Blood cultures taken February 18, February 20, February 24 were all negative. During this time her abdomen was markedly tender, particularly over the entire lower portion.

By the eighth postpartum day diagnosis of pneumonia involving the right lower lobe was made; no sputum, however, was typed. Pitting edema of both ankles developed. Following the irradiation on the eighth postpartum day there was temporary improvement in her general condition with moderate subsidence of fever. She persisted in this edema of the ankes. The pneumonia was apparently gone by the fourteenth postpartum day.

Periodic distention of the abdomen with rather marked tenderness across the lower portion and peaks of temperature to 102.8°F., pulse to 130 persisted until the twenty-second postpartum day when a diagnosis of abscess of the cul-de-sac was made and incision and drainage instituted plus 500 cm. of transfused blood. The patient's toxic symptoms became much more pronounced as well as periodic abdominal distention with marked pain and tenderness in the lower portion of the abdomen. Blood irradiation therapy was again performed on March 16, the twenty-eighth postpartum day, with no appreciable effect as far as im-

provement. By the thirty-third postpartum day it was decided after consultation that further drainage of the pelvis was necessary. With the
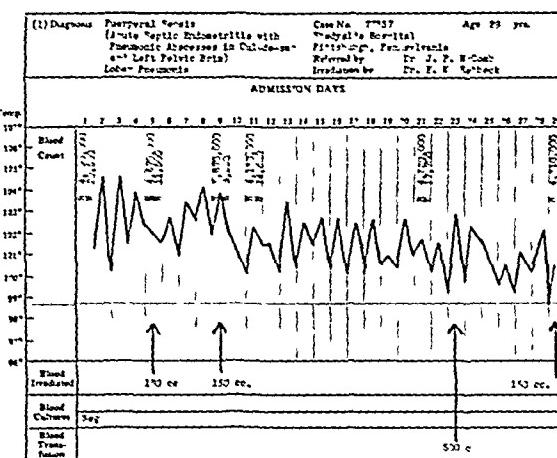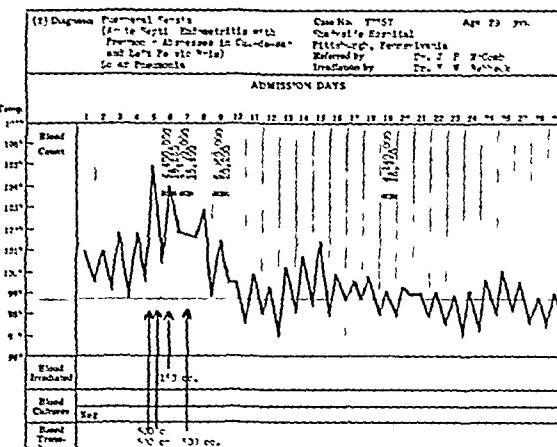
Fig. 13. Case XIII. No. 77357—Temperature graph.

preparation of 500 cm. of transfused blood a pelvic laparotomy was performed; an abscess was encountered with extensive involvement of the left pelvis. This was followed by another transfusion of 500 cm. of blood.

Despite the transfusions the patient continued desperately ill with high fever, and another blood irradiation treatment was given on the thirty-fourth postpartum day, March 22, when the temperature was 104°F., pulse over 160. Forty-five gr. of sulfapyridine were given in two doses prior to irradiation and then stopped. Cultures from both incisions and drainages showed predominance of pneumococci. In the first instance accompanied by bacillus coli and in the second by pseudomonas pyocyanea. Another 500 cm. transfusion was given on the thirty-fifth postpartum day from which the temperature gradually receded, the edema disappeared, the patient became rational, and she was discharged on April 22, 1939

or the sixty-seventh postpartum day, practically afebrile, in fair general condition with the abdominal incision granulating and scant drainage. The patient was last examined in September, 1940, at which time she had apparently made a complete recovery.

In reviewing the charts, we note that one patient developed a blood stream infection of non-hemolytic streptococcus gamma type despite sulfanilamide therapy. However, negative blood cultures were obtained the second day after the first blood irradiation. On several occasions it was necessary to give more than one irradiation before the patient was discharged, but in such instances the patient had a more favorable prognosis after the first treatment. We believe that in the difficult cases treated, many with advanced pathological conditions, that the high percentage of excellent clinical response is unmatched, in our experience, by any other type of therapy.

CONCLUSIONS

Our conclusions in the use of hemo-irradiation are:

1. The exposure of autotransfused blood to ultraviolet spectral energy, as outlined by the Knott technic, is a valuable and safe adjunct to the practice of medicine and surgery.

2. The biochemical background on this type of treatment is extensive and makes its use logical in indicated cases.

3. A definite reduction of toxicity is achieved.

4. In the treatment of puerperal sepsis it has exceptional value.

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THE TREATMENT OF SURGICAL AND TRAUMATIC SHOCK WITH A CITRATED PLASMA-SALINE MIXTURE*

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AN active surgical service is often confronted with a common and serious surgical emergency, secondary shock. It is admitted that no fixed standard can be set for shock; but for clinical purposes we have considered the following signs and symptoms present in whole or part as essential in the diagnosis of shock in the order of their importance: (1) Systolic blood pressure—8o mm. of mercury or less; (2) pulse accelerated but weak; (3) cool and moist skin; (4) pallor or slight cyanosis; (5) rapid and shallow respiration, and (6) thirst—rarely nausea and vomiting.

When two or more of the above clinical signs were present, the cases were treated for shock. However, of the six objective clinical criteria, the presence of a systolic blood pressure of 8o mm. of mercury or below was required as a part of any combination. There were three exceptions to this rule in the series. These cases exhibited all of the manifestations of secondary shock except that the systolic blood pressure ranged between 90 and 115 mm. of mercury. The normal systolic pressure for these three patients ranged from 150 to 220 mm. of mercury.

Moon[1] defines shock as a "circulatory deficiency, not cardiac nor vaso-motor in origin, characterized by a decreased blood volume, decreased cardiac output (volume flow) and by an increased concentration of the blood." Moon also states that the "mechanics for the circulatory deficiencies is the uncompensated disparity between the volume of blood and the volume capacity of the vascular system."

In secondary shock, this disparity is produced by the dilatation of the capillary bed with a resulting hemoconcentration, as evidenced by blood count and hematocrit determinations. As the pathological physiology progresses, there is a greater anoxia of the capillary cells which is followed by an increase in the permeability of the endothelium, thus allowing the plasma to diffuse into the extravascular spaces in large quantities, increasing the disparity between the volume capacity of the vascular system and the volume of circulating blood. The following chart from Moon's text on "Shock" is self-explanatory, and complete in its description of the vicious cycle of the pathological physiology of secondary shock.[1] (Fig. A.)

Based on this theory and work of Moon, the use of plasma seems to be the ideal agent to combat the disparity in the circulation system in secondary shock, as this is the agent lost; the colloids in the plasma exert the osmotic pressure necessary to hold the fluid within the vascular system.

Plasma and serum have been used by others: Mahoney,[2] in August, 1938, found that regenerated lyophilized plasma was

Lehman[6] described a simple syphoning method of preparing plasma in 1939. Hughes[7] and his group found a reduction of
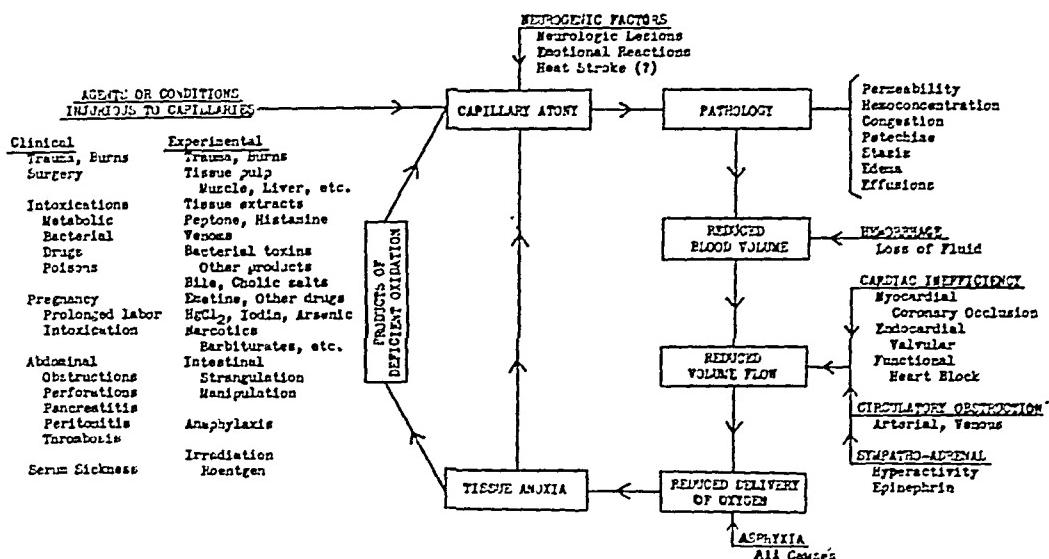
FIG. A. The vicious cycle. (After Moon.)

superior to whole blood, saline, or acacia in the treatment of experimental shock produced in dogs by cooling the peritoneal cavity, inducing an excessive loss of plasma.

In 1936, J. A. Elliott[3] described a vacuum system of drawing blood and preserving plasma. He suggested the use of plasma in the treatment of shock, but no mention of the actual clinical use was made. Bone and Wright[4] related the following conclusions on the use of lyophilized serum intravenously in shock produced in dogs by trauma to the gut or an extremity: "The blood pressure was raised and maintained for several hours by this procedure." They further stated, "The immediate availability of lyophilized serum—its theoretic stability and its action upon shocked animals suggests its use as a valuable treatment for clinical shock and hemorrhage."

Fantus[5] writes, "Serum would be more valuable than 6 per cent acacia solution in shock where there is little or no hemorrhage, and that blood serum would be a more rational treatment for shock produced by extensive burns, and that serum may furnish the principle of certain hemorrhagic conditions." No mention of the actual use of serum was made in this article.

increased intracranial pressure by the intravenous use of concentrated solution of human lyophilized serum. Levinson[8] and his associates presented an excellent study on the effectiveness of serum in the treatment of hemorrhage and shock in dogs.

McClure[9] in his discussion of the treatment of burns advises that "when the hemoglobin values are more than 15.6 gms., plasma transfusions should be given." Darrow[10] makes the following statement for the use of plasma in his article on the treatment of dehydration, acidosis, and alkalosis: "The maintenance of blood volume and circulation is essentially the treatment of shock—namely, blood or plasma transfusions, intravenous infusion of dextrose and at times of salt solutions."

Tatum, Elliott, and Messett[11] in December, 1939, described in detail a method of preparing plasma and the use of untyped or incompatible plasma in 191 cases without reactions.

Brodine and Saint Girons[12] "stressed the advantage of using plasma in place of whole blood in severe hemorrhages." They believe that the danger of hemorrhage lies in the loss of the volume of blood and much less in the loss of erythrocytes. "If the volume

of blood is reduced to one-fourth, death is inevitable." Recently, Strumia[13] and his group in a very complete report showed that "citrated blood plasma was the ideal means of restoring an adequate blood circulation in patients suffering from secondary shock, thus rapidly relieving the clinical manifestations of shock." Strumia[14] also writes that "serum gives reactions but citrated plasma does not."

Serum, citrated plasma, and regenerated lyophilized serum or plasma all seem to be clinically effective.

In view of the above overwhelming evidence of the value of plasma in the treatment of surgical shock, it was decided to make this therapeutic agent available in our hospital to meet his operative complication. During the past year we have utilized blood plasma as a by-product of the blood bank in eighty-one cases of secondary shock, using the above criteria as a basis for administration. The types of cases reported fall into two large groups.

Surgical Shock. The first type were those in which shock occurred during or after a surgical procedure. There were sixty-three cases in this group. Shock developed as late as forty-eight hours after the surgical procedure.

Traumatic Shock. The second type were those in which shock followed traumatic conditions outside the hospital, but excluding those in which there was gross hemorrhage. There were eighteen cases in this group. The plasma used in the treatment of these patients was prepared by two methods: The first by syphoning off the supernatant plasma from stored blood seven to ten days old and mixing with equal parts of saline. This was an open method and the plasma obtained by this method was used within twenty-four hours of preparation and stored at 4°C. The other plasma used in transfusions was drawn into vacuum bottles, stored at 4°C. for two to ten days, centrifuged for one hour at 2,000 revolutions per minute; and the supernatant plasma obtained from this outdated citrated blood was drawn into

another sealed vacuum bottle containing 250 cc. saline, the entire procedure being carried out under aseptic and closed system. The plasma prepared by this method was kept at room temperature (without preservatives in vacuum flasks containing 500 cc. of this equal mixture of plasma and saline, which had been previously serologically tested) for periods varying from one day to eight months after preparation.

In 500 injections we have had only two reactions. The first one occurred after the injection of 75 cc. of plasma. The patient complained of chilliness and a faint feeling. The infusion was discontinued immediately. Following this the patient developed a temperature of 104°F., but no further complications occurred. Culture of the plasma gave a Staphylococcus albus. The second reaction occurred in a patient with a severe pelvic peritonitis and hypoproteinemia. One half hour after the completion of the intravenous injection of 1,000 cc. plasma-saline, the patient developed a chill lasting twenty minutes, and this was followed by a temperature of 104°F. The patient had been showing septic temperature previous to the injection with daily variations between 100 and 103°F. No further complications developed and the patient was again transfused with a plasma-saline in a few days without any complications. The plasma used in each of these cases was prepared by the open (first) method.

The five following case abstracts and charts are presented as illustrative of the results obtained in group one, *occurring during or after surgical procedure:*

CASE REPORTS

CASE I. A colored male, aged fifty years, had osteomyelitis of the skull plate following a previous operation for a cerebellar tumor. Before the operation blood pressure was 160/110 and pulse 100. An ether ethylene anesthesia was administered. One hour after the operation began, blood pressure was 120/84 and pulse 120. During the next hour there was a

gradual drop of blood pressure and a rise of the pulse, so that one and one-half hours after the beginning of the operation, blood pressure was

sure was 120 100 and pulse rate 110. The patient showed none of the clinical signs of shock. One hour after the operation was com-
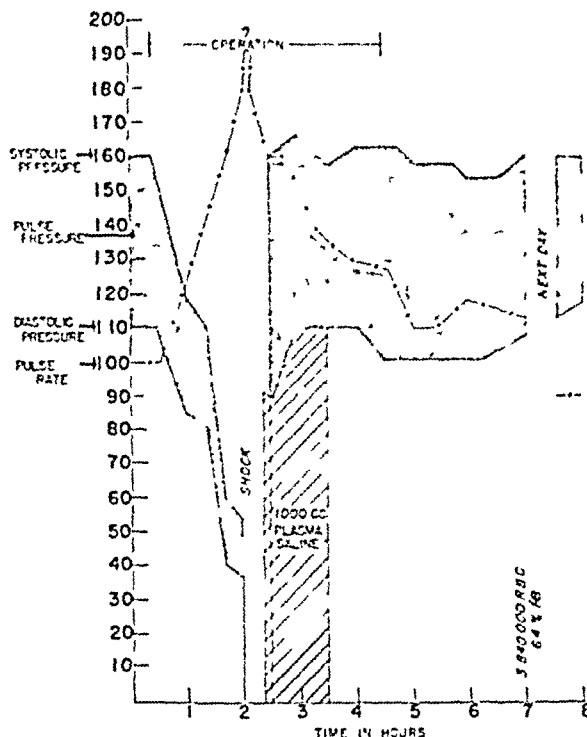
FIG. 1.

FIG. 2.

FIG. 1. Case I. Surgical shock. Removal of osteomyelitic skull plate.
FIG. 2. Case II. Surgical shock. Fibroid uterus; supravaginal hysterectomy and salpingo-oophorectomy.

60/40 and pulse 160. The other clinical signs of shock were now present. Fifteen minutes later, 1,000 cc. of a plasma-saline mixture was started intravenously. At this time blood pressure was 50/30 and the pulse too rapid to count. After receiving 250 cc. of the mixture, blood pressure was 160/90 and pulse 166. The remainder of the plasma was given during the next hour. Blood pressure was 155/110 and the pulse 140 at the completion of the intravenous injection. No clinical signs of shock were present. The operation, removal of the osteomyelite skull plate, took four hours, the pressure at this point being 160/100 and the pulse 126. During the next few hours the pulse gradually dropped to 110, the blood pressure remaining at 160/110. No evidence of latent or delayed shock occurred that day or the first postoperative day. (Fig. 1.)

CASE II.   A colored female, aged fifty-three, was admitted with a fibroid uterus. A supra-vaginal hysterectomy and bilateral salpingo-oophorectomy, which required one hour, was performed. Blood pressure and pulse before the operation were 144/100 and 94, respectively. At the end of the operation blood pres-

pleted, the patient was in surgical shock with a blood pressure of 60 45 and a pulse rate too rapid to count. One thousand cc. of a plasma-saline mixture was given intravenously with a gradual rise in the next hour of blood pressure to 90 60 and a fall of pulse rate to 116. The skin was dry but still cool. No other medication was given after this. There was a gradual rise in blood pressure with a drop in pulse rate in the two hours following completion of the intravenous administration to the normal level of 144/90 and 108. From then on the patient made an uneventful recovery. (Fig 2.)

CASE III.   A white female, aged thirty-eight, with unilateral pulmonary tuberculosis was operated upon for a third-stage thorocoplasty. Before the operation, blood pressure was 110/70 and pulse 86. During the operation, blood pressure dropped to 90 70 and pulse rate rose to 110. There were no other signs of clinical shock. Soon after the patient was returned to her room, her blood pressure dropped to 70/55 and pulse was 120 but very weak. The skin was cold and clammy. Before the plasma (500 cc.) was started the pulse had risen to 144. Within
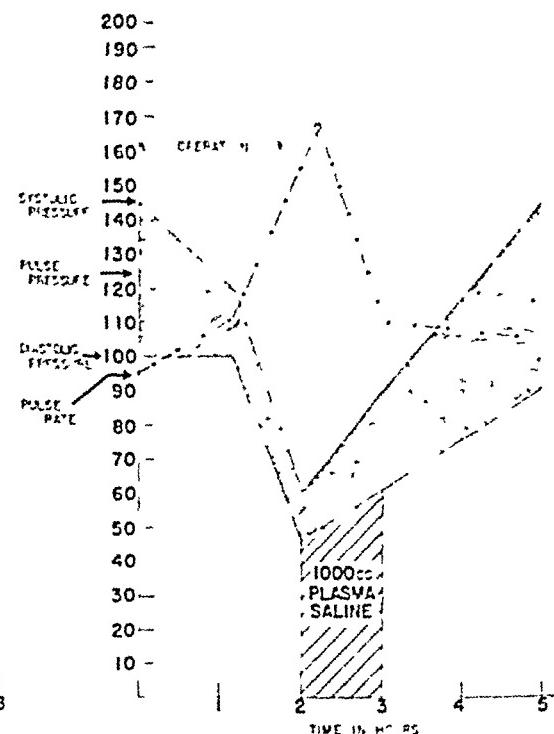
ten minutes after the plasma was allowed to flow intravenously, pressure was 90/70 and pulse rate 140. Twenty minutes later the pressure

There was a gradual rise in blood pressure and decrease in pulse rate during the next hour. Pressure was now 130/90 and pulse 108. Thirty
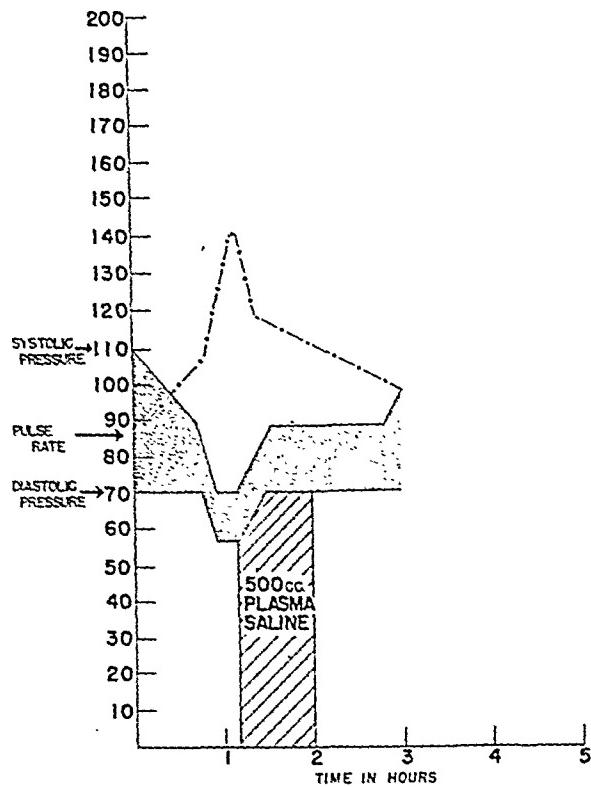
FIG. 3.

FIG. 4.

FIG. 3. Case III. Surgical shock. Thorocoplasty; pulmonary tuberculosis.
FIG. 4. Case IV. Surgical shock. Craniotomy; removal of pituitary tumor.

was the same but the pulse had fallen to 120. Forty-five minutes were required for the intravenous injection of the 500 cc. of plasma-saline mixture. Pressure was 100/70 and pulse 100 at this point. The patient made an uneventful recovery. (Fig. 3.)

CASE IV. A colored female, aged forty-two, was operated upon for a pituitary tumor. Blood pressure was 160/96 and pulse 84 before the operation. One and one-half hours after the operation began, blood pressure was 144/96 and pulse 100. The skin was cool and the patient was perspiring freely. One thousand cc. of 5 per cent dextrose in saline was given intravenously. After the infusion the blood pressure continued to drop. This clearly illustrated the ineffectiveness of crystalloid solutions in shock. One and one-half hours after the saline was given, blood pressure was 90/64 and pulse 130. The patient now exhibited all of the classical clinical signs of shock. In view of this, 1,000 cc. of plasma-saline mixture was administered. One half hour after the infusion was started, blood pressure was 120/70 and pulse 110. Operation was completed at this point.
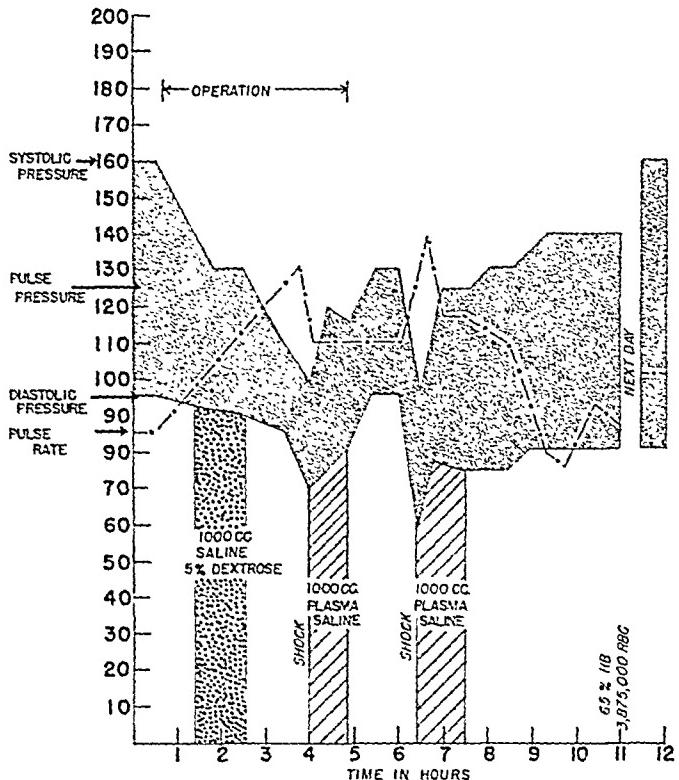
minutes later the patient was again in shock with a blood pressure of 84/60 and a pulse of 140. This demonstrated the necessity of close observation for the development of secondary shock. Plasma was not a complete protection. One thousand cc. of plasma was started immediately at this low level and there was an immediate response with the blood pressure returning to 120/74 and pulse 108. During the day there was a gradual rise of blood pressure to 140/80 and a fall of pulse to 80. The course was stormy. Coma developed and the patient died on the fifteenth postoperative day of cerebellar hemorrhage. (Fig. 4.)

CASE V. A colored female, aged thirty-six, was admitted with a large uterine myoma. Blood pressure and pulse before the operation were 110/60 and 86, respectively. At the operation, a right tubo-ovarian mass was found markedly adherent to an atrophied ectopic kidney. This was removed. During the latter part of the operation, which required an hour, the patient exhibited a blood pressure of 90/50 and a pulse of 120. One thousand cc. of 5 per cent dextrose in saline was given and the

patient responded for half an hour with a rise in blood pressure to 100/50 but no change in the pulse rate. One and one-half hours after the

Blood pressure was 110/70 and pulse 120. However, fifteen minutes later blood pressure was 80/55 and pulse 160. The patient mani-
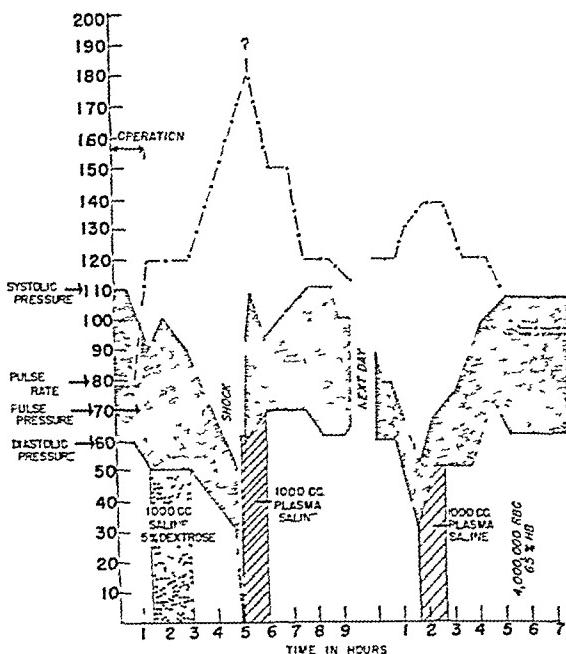
FIG. 5.

FIG. 6.

FIG. 5. Case v Surgical shock. Hysterectomy; removal of ectopic kidney.
FIG. 6. Case vi. Traumatic shock. Fractured femur, three ribs, bruises.

crystalloid infusion, the patient was in severe shock with all the classical signs and a blood pressure of 50/30. A few minutes later the blood pressure could not be obtained and the pulse was too rapid to count. One thousand cc. of a plasma-saline mixture was given. After receiving 300 cc. of the plasma the blood pressure rose to normal level in half an hour and the pulse dropped to 160. The course throughout the remainder of the day was satisfactory with a maintenance of a normal blood pressure and a gradual decline of the pulse rate to 120. The next morning blood pressure was 90/60 and pulse 130. The skin was a little cool and moist. During the next hour, the blood pressure fell to 50/20 and the pulse rose to 150. The patient was in secondary shock and 1,000 cc. of plasma-saline mixture was given. The blood pressure and pulse gradually returned to normal level. She made an uneventful recovery. (Fig. 5.)

The following two cases are typical of *traumatic shock without hemorrhage:*

CASE vi. A white male, aged fifty-six, was admitted after an automobile accident with a fractured femur, three fractured ribs and numerous bruises. The skin was dry and warm.
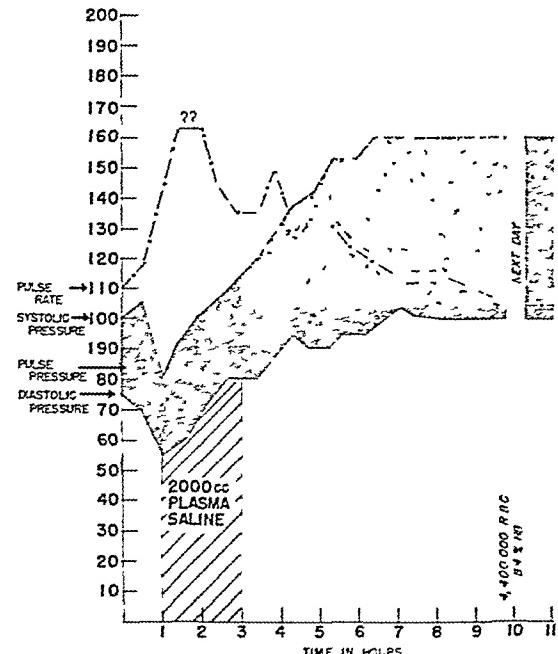
fested all of the classical signs of shock. Plasma-saline mixture was given immediately. One-half hour after the intravenous injection was started, blood pressure was 90/70 and pulse 160. One hour after the intravenous injection was begun, pressure was 100/70 and pulse 160. The patient's skin was still cold and clammy. Two thousand cc. of plasma-saline mixture was given. At the completion of the infusion, which required two hours for administration, blood pressure was 110/74 and pulse 130. Clinically, the patient was much improved at this point. Within the next two hours pressure gradually rose to 150/90 and pulse dropped to 120. The next hour showed a blood pressure of 160/90 and a pulse rate of 110. From this time on there was no change in blood pressure but a gradual decline of pulse to 100. His recovery was without incident but he was hospitalized a long period for treatment of the fracture of the femur. (Fig. 6.)

CASE vii. A young, colored male was admitted after an automobile accident which resulted in a fractured tibia, fibula, three ribs and a right Colles' fracture. At the time of admission the patient was in severe shock. No blood pressure was obtainable and the pulse

rate too weak and rapid to count. The skin was cold, pale, clammy and slightly cyanotic. Plasma-saline mixture was started immedi-

in this class responded immediately and made complete recoveries from shock with plasma infusions. (It is the added

Fig. 7. Case vii. Traumatic shock. Fractured tibia, fibula, three ribs and right Colles' fracture.

ately. After receiving 400 cc. the pressure had risen to 60/15 but the pulse was still very weak and rapid. Two thousand cc. of the plasma-saline mixture was given within the first two hours after admission. At this time there was a gradual rise in blood pressure to 90/50 and a fall of pulse to 120. At the end of the intravenous injection the patient's condition was much improved. There was steady improvement. The blood pressure returned to normal and pulse rate dropped to 110 two and one-half hours after admission. (Fig. 7.)

DISCUSSION

Surgical Shock. Case 1 is an example of the common occurrence of shock during an operative procedure. One-third of the sixty-three cases of surgical shock in our series were similar to the above. Case 1 demonstrated the active response of surgical shock to plasma. After receiving only 250 cc. of the plasma-saline mixture, this patient's blood pressure had risen to 160/90 from 50/32. All of the twenty-one patients

support which plasma gives this group which will, no doubt, allow more surgery to be performed at each operation.)

Cases ii and iii are prototypes of the frequent shock states occurring immediately or soon after surgical procedures. Both patients showed immediate and sustained response to plasma. The difference in doses between Cases ii and iii was determined by the size of the patient, clinical appearance of the patient, and the length of the operation.

The question might be raised at this point if cases of this type would not respond as well to infusion of glucose in saline. It is difficult to answer this question completely. We believe that many cases of surgical shock might respond well to crystalloid solutions if they are only in early and mild shock states. However, if the pathology has passed beyond this point and there already exists some increase in the capillary permeability, crystalloids will not suffice; and a

colloid preparation of plasma is required for permanent and efficient results. Previous to the use of plasma in our institution, most of the thorocoplastic patients received a blood transfusion immediately after operation. This is probably the custom among other thoracic surgeons. However, we now use plasma practically exclusively, since most thorocoplastic operations are not accomplished by excessive blood loss and our results have been all that could be desired. If a tuberculous patient is anemic, we treat anemia with repeated small blood transfusions pre- and postoperatively.

Cases iv and v represent shock treated with crystalloids without or with only minor reponse and also instances in which the shock states were severe enough not to respond completely and permanently to one plasma infusion. These examples serve to remove the impression which may prevail that one infusion of plasma is sufficient for secondary shock.

These cases also illustrate the importance of close observation postoperatively for delayed secondary shock which may develop in spite of what at first seemed to be adequate treatment. In Case iv, the delayed shock occurred one-half hour after a normal level had been reached. Case v did not go into delayed secondary shock until the day after the operation.

Traumatic Shock. Cases vi and vii exemplify the group of shock cases which occur as a result of traumatic conditions outside the hospital. This group is very common in this day and age as a result of traffic accidents. Case vi on admission was in a state of compensation and did not show the clinical signs of shock. However, we are sure that if a peripheral blood count had been done it would have shown hemoconcentration.

Blood pressure alone cannot be the pathognomonic sign of shock. Case vii was in severe shock on admission and treatment was started immediately in the accident room. He required 2,000 cc. of the plasma mixture to overcome his state of shock. Our experience has taught us that secondary

shock states (as a result of trauma outside the hospital) usually require more plasma than those which occur during or after the average operative procedure.

Case vii is the classical example illustrating the advantage of having a reserve supply of plasma. If this young man had come into a hospital without a blood bank or plasma bank, he probably would not have survived as the delay necessitated in obtaining donors and blood, probably would have been fatal. Even with a blood bank and without plasma, the minimum of a half hour is usually required to obtain blood for typing and cross-matching. Time consumed in administration of intravenous fluids may determine the outcome of the case. Cases vi and vii are similar to the shock states that occur in warfare and it is this group that would benefit the most by an immediately available unlimited supply of blood plasma.

COMMENT

Our results in eighty-one cases of secondary shock have been satisfactory in most cases and in some even spectacular. We believe that the use of plasma will be routine in surgical services in the treatment of shock. Plasma is particularly an important adjunct to the small hospital. A blood bank as a rule has not been feasible in a small institution where the number of transfusions is less than two a day. A previous report from our blood bank showed that to maintain an adequate supply of blood of all types, at least three transfusions per day were required and a supply of fifteen pints of blood.

Naturally, this is not practical in the small hospital; but with plasma, all of the out-dated blood can be readily converted into plasma and stored for long periods, thus eliminating any waste and assuring the presence of an effective fluid for all emergencies. This will lead to a "Blood-and-Plasma Bank" in place of the "Blood Bank." Likewise, with modern equipment, the simplicity of preparation and handling

of plasma offers an unlimited demand and use. The ordinary transfusion without a blood bank requires the typing of the patient, typing or serological tests upon the donor, venesection and cross-matching before transfusion. Conservatively speaking, this requires at least one to two hours to perform. With a blood bank system, a transfusion requires only typing of the patient and cross-matching of the donated blood. This procedure takes at least one-half hour to be carried out carefully and accurately. Plasma eliminates all of this since it requires no typing, and serological tests have been performed before the plasma is available for use.

Another important advantage of plasma is the absence of reactions as compared to preserved whole blood. Personal records of 2,000 whole-blood transfusions revealed a 6.3 per cent reaction rate of which 0.4 per cent were severe. Plasma eliminates the emergency from emergency transfusions. We believe that in surgical shock, plasma is equally as efficacious if not superior to citrated preserved blood.[15]

The simplicity and ease of storage is another important advantage. Plasma may be stored at room temperature or refrigerated at 4°c. This advantage will probably give the use of plasma a place in military service.

Previous to the use of plasma in our institution, approximately 5 per cent of the banked blood was discarded because it was too old and partly hemolyzed. Plasma has completely saved us this loss, and obviated the necessity of holding blood to the end of a maximum safe-storage period.

The dose of plasma required in different cases depends entirely upon the etiological factors, the duration and severity of the shock. The best way to answer this is to say that the dose is as much plasma as is required to obtain results. We have obtained results in some cases with only 250 cc. of plasma and in others as much as 2,000 cc. was required for a response. Four thousand (4,000) cc. of incompatible or untyped plasma has been given by us to

one individual in a continuous intravenous drip.

With the advent of the use of plasma in our institution, we have replaced whole blood transfusions with plasma transfusions in many cases of shock and it has proved clinically most satisfactory.

During the earlier stages of our work with plasma, we often confronted men on our staff who hesitated to use plasma; but now the pendulum has probably swung too far, and plasma is being used very freely here. Time and further study will, no doubt, bring the pendulum back to a more normal arc.

SUMMARY AND CONCLUSIONS

1. Eighty-one cases of surgical and traumatic shock (secondary shock) were treated with a 1-to-1 plasma normal saline mixture that was prepared by centrifugation from out-dated preserved citrated blood. The results were satisfactory in most cases and in some even spectacular.

2. No typing, cross-matching, pooling or heating of plasma was performed before intravenous administration.

3. Plasma may stand at room temperature or refrigerated at 4°c. It has been stored for long periods at room temperature in vacuum containers for eight months.

4. Only two reactions occurred in over 500 intravenous administrations.

5. Large and repeated doses can be given without any obvious complications.

6. The use of plasma eliminated the time consumed in transfusions of whole blood, for it is always ready for immediate use.

7. The more frequent use of plasma will materially aid any active service in the preparation and care of surgical patients.

8. It will probably prevent many cases of delayed surgical shock.

9. The small hospital can conveniently maintain a "Blood-and-Plasma Bank."

10. Plasma offers to the medical services of the armed forces a substitute for whole blood that can be handled with ease under many varied conditions.

11. The loss of out-dated blood that occurs in a blood bank is removed with the use of plasma.

We wish to thank Dr. J. Ross Veal and Dr. J. A. Parks for their co-operation, advice and use of their surgical cases, and Dr. Edgar A. Bocock, Dr. P. S. Rossiter, and Dr. C. C. West for many facilities.

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A NEW OPERATIVE PROCEDURE FOR DUPUYTREN'S CONTRACTURE*

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CONTRACTED fascia is the underlying cause of Dupuytren's contracture. Usually the palmar fascia and its deep extensions to the interosseous fascia are involved.

The principal reason for failing to obtain a permanent cure of the deformity has been the lack of a systematic method for removing all of this contracted fascia. The procedure to be described should lower the high incidence of recurrences after operations for this condition.

The standard textbooks of anatomy give adequate descriptions of the palmar fascia. Some describe the deep extensions to the interosseous fascia. These deep extensions, it will be recalled, help to form canals for the lumbrical muscles, the digital vessels and nerves and the long flexor tendons. It is surprising to find that the text books on surgery as well as the special articles on Dupuytren's contracture invariably lack a detailed method for the complete removal of all of the fascia which may be contracted in this condition.

Regardless of the type of skin incision used it is the general concensus of opinion that the contracted palmar fascia must be removed. Contracture of the deep extensions may contribute to the flexion deformity as much as contracture of the palmar fascia. Removal of these deep extensions in addition to the removal of the palmar fascia is, therefore, essential for a permanent cure of the condition.

The surgeon who is cognizant with the importance of thoroughly removing all the contracted fascia may be restrained from completing a thorough dissection by the fear of injury to the digital vessels and nerves. He usually proceeds to strip the palmar fascia away by sharp dissection, and with his attention fixed on protecting the vessels and nerves may leave strands of this fascia behind. If he appreciates the importance of removing the deep extensions, this may be accomplished in an incomplete and unsatisfactory manner, with the result that the operation may fail to correct the deformity or the deformity is only partially corrected.

After careful dissection of the skin and part of the subcutaneous tissue from the palmar fascia, the method devised by me consists of immediately locating the course of the digital blood vessels under the palmar fascia by palpation. No tourniquet is used and the pulsations of the arteries are easily felt. The vessels with the digital nerves run in canals between the tendon sheaths of the long flexors of the fingers. The course of the tendons in their sheaths under the palmar fascia are in turn easily identified by extending the fingers. No attempt is made to strip off the palmar fascia, but instead this fascia is removed with its deep extensions to the interosseous fascia in the following manner:

A series of longitudinal incisions are made directly over the tendon sheaths and over the canals for the blood vessels and nerves. (Fig. 1.) To prevent injury to the tendons, blood vessels and nerves, a grooved director with a rounded but rather small pointed end is inserted immediately under the palmar fascia, in a proximal direction, and each incision is made through the palmar fascia down to this grooved director. In this manner the canals for the tendons, and for the blood

vessels and nerves, are opened without injury to the underlying structures.

Two adjacent cut edges of the palmar

3.) In this procedure the vessels, nerves and tendons on either side of the partition are protected by retraction. This deep exten-
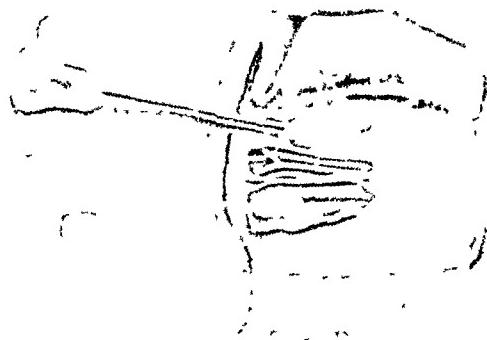
Fig. 1. Dissection of palmar fascia. Longitudinal incisions are made upon a grooved director inserted under the palmar fascia. One such incision made has exposed the long flexor tendons to the ring finger. Another has exposed the digital vessels and nerve between the ring and middle fingers. (Skin incisions shown are for clarifying steps in the procedure.)
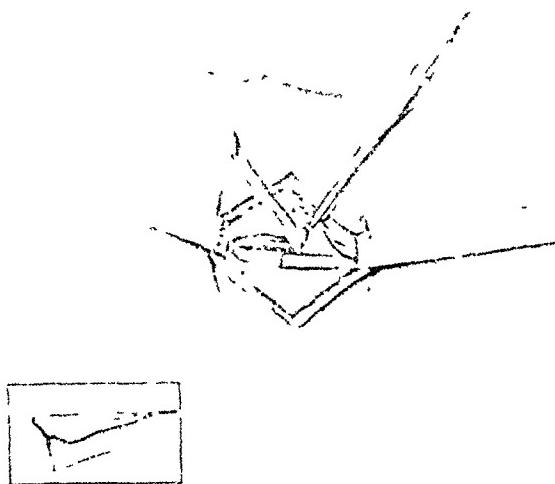
Fig. 2. Excision of deep extension with attached portion of palmar fascia. Insert: Resected deep extension with its adjacent palmar fascia.

fascia are secured in a hemostat just distal to the transverse metacarpal ligaments. (Fig. 2.) Traction is made proximally and upward, and at the same time the deep extension or partition from the underside of the palmar fascia is put on the stretch. This deep extension (and immediate adjacent portion of palmar fascia) is removed by incising deep down along the line of its reflection to the interosseous fascia. (Fig.

sion or partition will usually be found to terminate proximally along a convex line, which corresponds to the location where the tendons diverge from the common palmar bursa. The individual partition when removed (Insert Fig. 2) will have an irregular shape; its upper margin will be continuous with a flange of palmar fascia extending between two adjacent longitudinal incisions first made; its lower margin

will represent the line of its attachment to the interosseous fascia.

The number of longitudinal incisions made and, therefore, the number of deep

marked flexion deformity involving the third, fourth and fifth fingers. The above operative procedure resulted in the correction of the deformity with no recurrence.
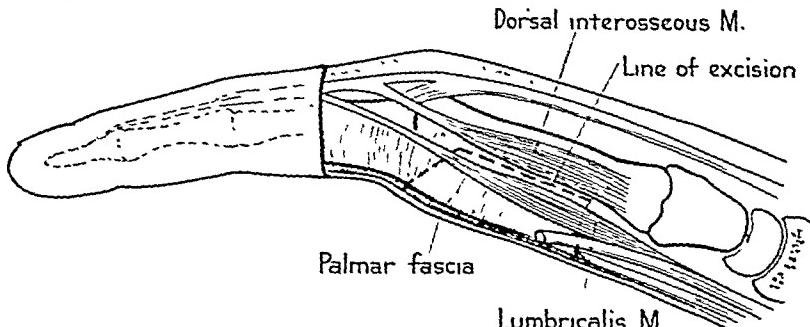
FIG. 3. Diagram shows line of excision of deep extension and attached part of palmar fascia, viewed from the side.

extensions removed will depend upon the individual case. Usually the middle, ring and small fingers are involved in the contracture. This would necessitate six longitudinal incisions: (1) over the long tendons to the little finger; (2) an incision over the canal between the little finger and ring finger; (3) another incision over the long flexor tendons to the ring finger; (4) one over the canal between the middle and ring fingers; (5) another over the long flexors of the middle finger; and (6) one over the canal between the index and middle fingers. In this manner the greater part of the contracted palmar fascia together with five deep extensions would be removed. An additional strip of palmar fascia may be removed from the lateral aspect overlying the tendons to the little finger.

Should the index finger also be involved, two additional incisions would be necessary: (1) over the tendons to the index finger, and (2) over the lumbrical canal on the radial side of the index finger. Practically the entire palmar fascia would thus be removed together with seven deep extensions.

By following this procedure the operating time may be markedly shortened while the maximum amount of contracted fascia can be removed with the least danger of injury to the blood vessels, nerves and tendons.

The following report is of a patient with Dupuytren's contracture who had a

CASE REPORT

Miss C. C., age twenty-four years, gave a history of having had repeated attacks of rheumatic fever starting at the age of thirteen years. Her tonsils had been removed three years before this. During the first attack of rheumatic fever, her knees, ankles, shoulders and elbows were involved but these cleared up after being in bed for six weeks. She was left with a contracture of the third, fourth and fifth fingers of the right hand.

In an attempt to hide this deformity, she used to carry a handkerchief in this hand more or less constantly. She had made no attempt to have her fingers straightened out until she found that this deformity interfered with her social engagements. The rest of her history was irrelevant.

Physical examination revealed a well developed and well nourished, rather attractive young woman with a typical Dupuytren's contracture of the right hand involving the third, fourth and fifth fingers. The joints of these fingers were not ankylosed. With a forceful but unsuccessful attempt to extend these fingers strong contracted fascial bands could be seen and felt under the skin of the palm. The rest of the examination was essentially negative.

An attempt was made to see what improvement would result from active manipulation, stretching, repeated hot and cold soaks, and electric stimulation and massage of the long extensor muscles of these fingers. A corrective glove was designed with pockets on the dorsum of the three fingers for slips of spring steel. After eight weeks of diligent effort along these

FIG. 4.

FIG 5.

FIG. 4. Shows the contracted fingers before the operation.
FIG. 5. Shows the hand one month after the operation.
Note the slight hyperextension of the fourth and fifth
fingers now possible, and the linear healed scar in the
distal flexion crease of the palm

FIG 6.

FIG. 7.

FIG. 8

FIG. 9.

FIGS. 6, 7, 8 AND 9 Four years after the operation. No recurrence
of the contractures Complete functional restoration of the
fingers.

conservative lines no improvement whatsoever was noted and operation was advised.

Under general anesthesia a 2-inch incision was made in the distal palmar crease of the hand. The skin and part of subcutaneous tissue was dissected away from the palmar fascia all around the incision. The palmar fascia was found markedly thickened and contracted. The anatomical locations of the long tendons to the three outer fingers and intervening lumbrical canals were determined, and then each passageway was opened by longitudinal incisions made upon a grooved director first inserted under the palmar fascia as described above. The fascial septae or deep extensions from palmar fascia to interosseous fascia were likewise found thickened and these were completely removed. Four such deep extensions were removed together with the palmar fascia which had covered the lateral half of the palm. There was very little bleeding, and after the resection of the fascia the fingers could be straightened out with ease. The flexor tendons were not lengthened. The incision edges in the skin and subcutaneous tissue were then approximated with interrupted silk sutures, and a volar splint applied.

Manipulation of the fingers was started on the third day after the operation. The patient left the hospital after four days, but was seen frequently at the office during the following three weeks. The patient was given active and passive exercises for her fingers. The wound healed by primary union. The functional correction of the contractures was very satisfactory; the scar in the palmar crease was hardly noticeable.

Four years later there was no evidence of any recurrence of the deformity. (Figs. 4 to 9.)

SUMMARY

1. A procedure for a more complete removal of the palmar fascia and its deep extensions in Dupuytren's contracture is described.

2. A case report is given in which this procedure resulted in complete functional restoration. No recurrence of any contracture was noted after four years.
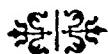
THE PREPARATION OF SUPERFICIAL WOUNDS FOR SKIN GRAFTING BY THE LOCAL USE OF SULFANILAMIDE AND SULFANILAMIDE-ALLANTOIN OINTMENT*

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THERE are several methods of preparing superficial granulating wounds for the reception of skin grafts. The most

many cases require the use of skin grafts. These include extensive body burns, traumatic wounds, postoperative skin defects,
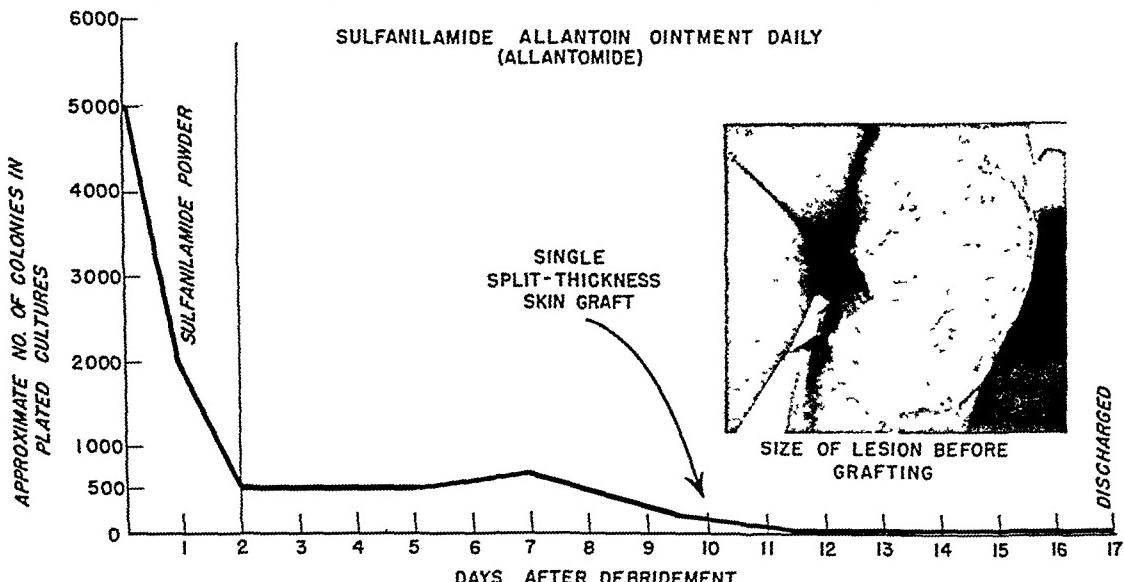
Fig. 1. Chart showing rapid control of infected second and third degree burn of buttocks, following débridement and the topical application of sulfanilamide and sulfanilamide-allantoin ointment. Entire lesion grafted at one stage. Note position and size of lesion on buttocks.

successful has been continuous wet dressings or irrigations with normal saline solution and mild antiseptics. These measures require expert management and constant attention. In some parts of the body they are difficult to apply and are annoying to the patient. A more simple and effective method has long been needed. This need seems to have been fulfilled with the introduction of the sulfonamides. The results obtained by the local application of sulfanilamide and sulfanilamide-allantoin ointment in preparing some forty superficial ulcerations for skin grafting forms the basis for this report.

In a large surgical service, such as we have at the Gallinger Municipal Hospital,

amputation stumps and chronic leg ulcers. Practically all such lesions are contaminated or grossly infected. The chief aims of treatment should be the control of the infection and the promotion of the natural processes of healing. The healing time of granulating wounds depends upon the size, depth, vascularity, location and the activity of the infecting organisms. Many of the smaller superficial ulcers will heal promptly if they are kept clean and the growing epithelium is protected. The healing time of the larger ulcers may be tremendously shortened by the use of autogenous skin grafts. However, in order to apply skin grafts successfully to such lesions the field must be properly prepared. The bacterial

activity, or infection, must be inhibited and an adequate blood supply of the granulating bed promoted. In a recent communica-

trolled. Prolonged local use of the pure drug may slow the healing process in granulating wounds by inhibiting the

Fig. 2. A, photomicrograph of granulation tissue of ulcer after controlling infection by the local application of sulfanilamide. Note the scant number of blood vessels. B, same area of ulcer after ten days' application of 2 per cent allantoin. Note increased vascularity and also the exacerbation of infection. C, same area after being treated by the local application of sulfanilamide-allantoin ointment for ten days. Note the marked decrease in infection with the maintenance of adequate blood supply.

tion[1] we outlined the technic used in combatting local infection in pyogenic wounds by the topical application of sulfanilamide and sulfanilamide-allantoin ointment. The same routine has been highly effective in controlling the infection in superficial granulating wounds. After proper application of this form of treatment, these wounds have been found to be in an ideal state for the reception of skin grafts.

Sulfanilamide, when applied directly to an infected or contaminated wound, inhibits bacterial growth according to the degree of concentration of the drug. Its action is a direct one, and the drug must come into actual contact with the organisms to be effective.[2] This means that the lesion to be treated must be adequately débrided and all parts made accessible. Sulfanilamide inhibits the growth of all the common organisms found in surface wounds. Among these are the various strains of staphylococci, streptococci, the colon-dysentery group, diptheroids and Bacillus pyocyaneus. A single application of the pure sulfanilamide does not sterilize the wound. A fresh supply must be added daily until the infection is completely con-

vascularization of granulation tissue and retarding the growth of new epithelium.[1,3]

We have found that by substituting sulfanilamide-allantoin ointment for the concentrated powder after the infection has been controlled active healing will quickly revive. Robinson[4] has previously demonstrated that allantoin has a stimulating effect upon epithelization by increasing the vascularity of granulation tissue. The sulfanilamide-allantoin ointment (allantomide) contains 10 per cent sulfanilamide and 2 per cent allantoin in a special base. This amount of sulfanilamide prevents reactivation of the bacterial growth and yet does not produce a harmful effect on the delicate new epithelial cells. Two per cent allantoin has proved sufficient to promote rapid development of blood vessels in the granulation tissue. The base[5] of this ointment contains stearic acid, triethanolamine and glycerine, which is greaseless and apparently insures complete liberation of both the active ingredients.

The following method has now been used in preparing more than forty cases of superficial ulcerating areas for skin grafts. It has proved highly successful and quite

simple in application. The first measure is that of making the entire surface of the lesion accessible to the local application of

the sulfanilamide powder. All necrotic and nonviable tissue is removed and all pockets and undermined regions are adequately drained. In the more extensive lesions a suitable anesthesia should be used for this procedure. After hemostasis has been secured a sufficient quantity of the pure sulfanilamide is applied to cover completely the entire surface of the wound. The amount used, of course, varies with the size and character of the lesion under treatment. From 2 to 10 Gm. may be safely used in the grossly infected wounds. The rate of absorption from such lesions is slow and the total amount absorbed into the blood stream is smaller than when the drug is given by mouth or parenterally. We have

Fig. 3. Intractable furunculosis of axillary pad. Entire area excised; control of infection with sulfanilamide powder; preparation of granulation tissue for skin graft with allantoin-sulfanilamide ointment; successful single split thickness graft. A, showing sulfanilamide powder applied to surface of lesion. B, healed graft.

seen no evidence of any systemic toxic reaction following local application of sulfanilamide or sulfanilamide-allantoin ointment in more than 300 cases of pyogenic wounds. After instillation of the powder the wound is simply covered with a dry gauze dressing. A new dressing with a fresh supply of sulfanilamide is applied daily until the infection is completely controlled. At this stage many of the small ulcerated areas will be found ready for the application of a skin graft. In the case of the larger ulcers and extensive burns, however, the granulation tissue is often pale, anemic and poorly vascularized. Such cases require correction of this deleterious action of the drug before a grafting operation is undertaken. The allantoin-sulfanilamide ointment (allantomide) is very efficacious for this stage. (Fig. 1.) The pure sulfanilamide is discontinued and the granulating surface is lightly covered with the ointment. It may be spread directly upon the surface or applied on a gauze dressing. These dressings are applied daily. Within a few days after beginning the use of the ointment the granulation tissue begins to grow actively and becomes more healthy in appearance. Biopsies taken from such wounds actually show many small new blood vessels growing into the granulation tissue. (Fig. 2.) The bacterial activity remains inhibited. As soon as the granulation tissue becomes bright pink in color and bleeds freely when traumatized, the ulcer is considered ready for grafting. (Figs. 3, 4, and 5.)

We have employed the same immediate operative preparation in all cases. The patients receive a suitable anesthetic. The recipient field is scrubbed with green soap and water. The donor areas are prepared by ether, iodine and alcohol. The granulation tissue is pared down with a sharp scalpel and complete hemostasis secured. Several types of skin grafts have been employed in the present series of cases. In the majority of instances, however, the split thickness skin graft has been used. The Padgett dermatome[6] has simplified the taking of this type of graft and has made it

the most practical of all. By this technic a graft of almost unbelievable size can be used at one operation. The postoperative stage we have applied sulfanilamide-allantoin ointment dressings to the ungrafted area while awaiting the next stage. (Fig. 6.)

FIG. 4. Extensive streptococcic and gas bacillus infection of leg with skin gangrene. Rapid control of infection by the topical application of sulfanilamide after débridement; granulation tissue prepared by sulfanilamide-allantoin ointment. A, granulation tissue ready for graft. B, successful graft in one stage.

FIG. 5. Carcinoma of face with gross infection; excision; control of infection by topical application of sulfanilamide and sulfanilamide-allantoin ointment. A, carcinoma of face before excision. B, granulation ready for graft. C, healed graft.

care of the grafts has varied considerably, but in all cases the grafted part has been immobilized. When the entire granulating surface has been covered at one stage, we have used wet and dry dressings with equal success. In those cases in which only a portion of the lesion was grafted at the first

This dressing has maintained control of the infection and has not interfered with the "take" of the graft.

SUMMARY

Sulfanilamide has proved to be an excellent local agent in combatting bacterial

growth in infected and contaminated surface wounds. The action of the drug is a direct one and must come into contact with the invading organisms. Prolonged use of

We wish to thank The National Drug Company, of Philadelphia, Pennsylvania, for furnishing us with the allantomide used in this study.
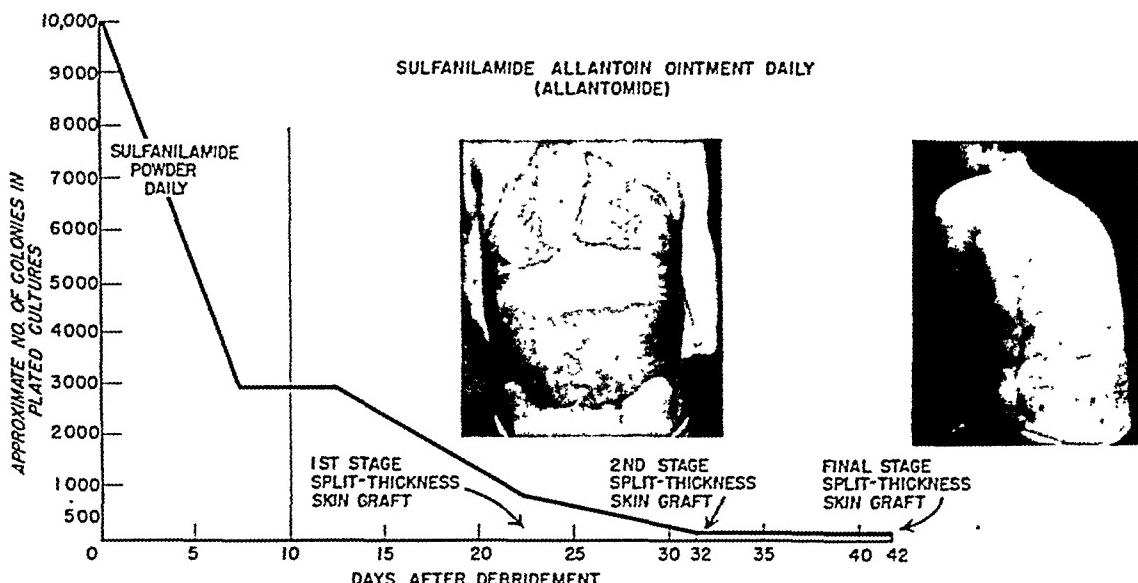
FIG. 6. Chart showing rapid control of infection by sulfanilamide locally in extensive second and third degree burn of back following débridement. Preparation of granulation tissue for skin graft by topical application of sulfanilamide-allantoin ointment. Note size of graft used and the healthy appearance of granulation tissue.

the pure drug may retard healing. Complete removal may allow a reactivation of the infection. Both of these disadvantages may be averted by substituting sulfanilamide-allantoin ointment for the pure powder after the infection has been controlled. The allantoin promotes active vascularization of the granulation tissue thereby creating a favorable state for the reception of skin grafts. The excellent results obtained by preparing some forty superficial wounds for skin grafting by the local use of sulfanilamide and sulfanilamide-allantoin ointment (allantomide) has been most encouraging. The method is simple and applicable to all areas of the body.

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THE USE OF A PLASTER SLIPPER IN THE MANAGEMENT OF SIMPLE FRACTURES OF THE TOES*

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THE purpose of this article is to present a practical form of light plaster support which affords comfort, protection and relative immobilization for minor fractures of the toes. It is simple to construct, may be removed quickly and reapplied with ease. Many methods have been suggested for attaining these objectives. They vary from simple adhesive strappings to circular plaster casts which include both the foot and toes. The simpler methods frequently do not provide sufficient stability and protection for the broken phalanx. The more sturdy supports provided by plaster boots or malleable aluminum forms seem cumbersome to the patient and are usually time consuming in their application.

TECHNIC

Measurements of the foot and ankle are taken from the anterior intermalleolar line over the dorsum of the foot, across the tips of the toes, back beneath the plantar aspect of the foot and heel, and up to the posterior intermalleolar line.

FIG. 1. This illustration indicates the method of taking the measurements.

FIG. 2. This photograph shows the method of applying the plaster to the foot.

(Fig. 1.) Two strips of cotton flannelette four inches longer than the required length and six inches wide are laid out on the plaster table. Strips of plaster are constructed (dry) with four to six inch rolls. The length of the strips correspond with the original measurements taken of the foot. Eight to ten thicknesses of plaster are sufficient. The patient's foot is then carefully bathed, dried and powdered, especially between the toes. Small squares of cotton are placed between the digits. The fractured toe can be further immobilized with crossed adhesive strips, if this seems advisable. The bony prominences of the tarsal bones, the base of the fifth metatarsal, the head of the first metatarsal and the heel are then protected with a few thicknesses of sheet wadding. The plaster is dipped and laid out smoothly

on one of the above mentioned flannel strips. The edges of the flannel are folded along the sides and ends of the plaster in

desirable to allow the patient to walk, a wooden block heel and square wooden sole may be placed in the folds of the

FIG. 3. This picture demonstrates the proper method of applying and removing the mold.

FIG. 4. The above illustration presents the cast molded to the foot.

order to cover all rough edges. The strip is then applied to the foot and gently molded to the peculiarities of the individual extremity. (Fig. 2.) When the plaster has begun to harden, an ace bandage is applied evenly and snugly to maintain constant pressure on the mold. It will be found that when fully hardened the plaster can be removed easily by gently separating the dorsal from the plantar portion of the cast. (Fig. 3.) The plaster usually possesses enough flexibility at the toe angle to allow this adjustment without cracking. The mold can be easily replaced and secured with the bandage. (Fig. 4.) If it seems

mold before the plaster is applied to the foot.

CONCLUSION

Simple fractures of the toes in which the fragments tend to remain in satisfactory position are not as a rule difficult problems in management. It is, however, important to provide comfort for the patient and stability for the fragments while the healing process is in progress. The type of cast presented in this paper can be worn with comfort, is easy to apply and affords the fractured phalanx adequate protection and support.

OBSTRUCTION OF THE COMMON BILE DUCT
BY A DETACHED PIECE OF LIVER*

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IT is most unusual to find a detached piece of liver so firmly wedged in the ampulla of Vater that it produces both an obstructive jaundice and a persisting external biliary fistula. The pathogenesis of this bizarre complication is so easily understood when viewed in retrospect.

CASE REPORT

Mrs. M. McD., a stenographer, forty-two years of age, entered the hospital because of an "acute abdomen." During the past five years she had had recurrent attacks of flatulence, indigestion and mild, colic-like pains in the right hypochondrium. Four days previous to entering the hospital, she was seized with persistent nausea and vomiting. Palliative treatment proved ineffective.

Physical examination gave evidence of a profound toxemia. The lips were excoriated by herpetic ulcers, the tongue was dry and furrowed, and the breath was decidedly acidotic. The entire epigastric area possessed a board-like rigidity and the remaining portion of the abdomen was tympanitic. No peristaltic sounds were audible. The temperature varied from 99.2 to 103.2°F. and there were 18,000 leucocytes with an 88 per cent neutrophilic count.

Emergency treatment consisted of gastric decompression, inhalation of oxyen, hot fomentations to the entire abdomen, morphinization, and the intravenous administration of 3,000 cc. of 5 per cent solution of glucose in physiologic saline. Even this rigorous therapy failed to arrest the storm and an immediate laparotomy was advised for fear that the gallbladder had undergone gangrenous changes and perforated.

The peritoneal cavity was opened through a right rectus incision and a large, tense, acutely inflamed gallbladder immediately presented itself. The common bile duct was enlarged and indurated but no stones could be palpated. The pancreas was swollen, firm and edematous. Fifty-five cc. of thick purulent bile were aspirated from the gallbladder and on opening this decompressed viscus, its gangrenous mucosa was found to be completely detached from the underlying muscularis. No difficulty was experienced in extirpating the necrotic membraneous lining as it came away en masse, forming a distinct cast of the gallbladder cavity. Five facetted stones were removed from its lumen, one of which had become impacted into the orifice of the cystic duct. Digital exploration revealed an ulcerative perforation of the posterior wall of the gallbladder and two small stones were removed from the contiguous liver abscess. The patient's condition was so serious and the cholangitis and pancreatitis were so extensive that further exploration seemed unwarranted, therefore, a simple cholecystostomy was performed.

The immediate postoperative course was most pleasing except that the stools remained acholic for all the mucopurulent bile escaped from the external fistula. This was not unexpected as the inflamed pancreas was capable of producing a compressive occlusion of the ampullic portion of the common bile duct. In order to obtain accurate information concerning the functional status of the biliary tree a deferred cholangiogram was made on the eighth postoperative day. The gallbladder and cystic duct appeared to be normal but the ampullic segment of the choledochus was obstructed so that the contrast fluid could not enter the duodenum. The location and contour of the occluding lesions strongly suggested the presence of a stone. (Fig. 1.)

Several attempts were made to dislodge the calculus by means of the "biliary flush." Physiologic doses of amyl nitrite and atrophine

hepatic abscess which was easily evacuated. Ten days were required for the toxic reactions to subside. During this interval, she received
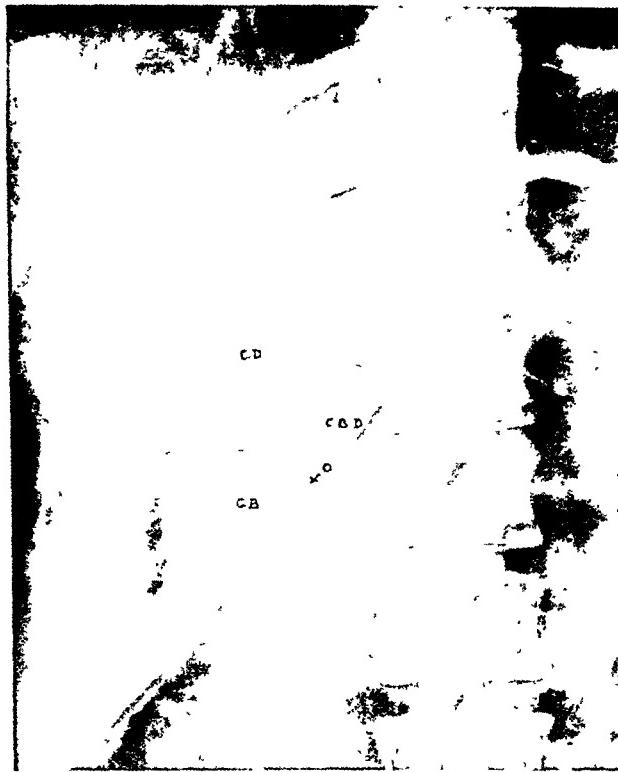
FIG. 1. Postoperative cholangiogram visualizes the gall-bladder (GB), the cystic duct (CD), and the dilated common bile duct (CBD). The contrast fluid could not enter the duodenum because of an ovoid filling defect which completely obstructs the ampulla of Vater (O). Calculus?

sulfate were given to relax the sphincter of Oddi, following which the common bile duct was subjected to positive pressure lavages with warm olive oil. The results were most disappointing. As Best and Hicken[1] had successfully employed the biliary flush in other cases it was believed that our failure was due to an extensive pancreatitis producing a compressive occlusion of terminal choledochus. The patient was permitted to go home; we hoped that prolonged T-tube drainage would permit the cholangitis and associated pancreatitis to subside.

Four weeks later she was re-admitted to the hospital complaining of chills, fever, colicky pains and jaundice. Copious quantities of purulent bile drained from the T-tube. The soft tissues in the right hypochondrium were swollen, tender and very painful. A curved hemostat was passed along the outer margin of the drainage tube until it entered the sub-

intense vitamin therapy and two transfusions of whole blood. A second exploration was deemed advisable.

When the patient was on the operating table, 45 cc. of diodrast* was injected into the cholecystostomy tube. The gallbladder, cystic duct, hepatic abscess and all the dilated bile ducts were clearly visualized. The ampulla of Vater contained an irregular ovoid "filling defect" which was thought to be an obstructing calculus. (Fig. 2.)

The common bile duct was opened and two pieces of bile-stained tissue were removed from its lumen. No other obstructive lesions could be detected, hence a T-tube was placed in the duct and a second operative cholangiogram was made. This revealed the common bile duct to be patulous for the contrast fluid had already

* Diodrast (70 per cent by weight volume) supplied by the Department of Medical Research of the Winthrop Chemical Company.

passed into the duodenum. (Fig. 3.) The gall-bladder was removed in a retrograde manner and the perforation of its posterior wall was clearly demonstrated. The contiguous liver substance was necrotic, shaggy and was covered with plastic exudate. Apparently this was the origin of the migratory pieces of liver which plugged the common bile duct.

The convalescence was uneventful and very rapid. A deferred cholangiogram was taken on the eighth postoperative day and all the bile ducts were found to be functioning normally. The T-tube was, therefore, removed and the external sinus closed within the next three days. She returned to her former occupation on the eighteenth postoperative day.

The pathologist's report was as follows: "Two pieces of bile stained tissue measuring $1\frac{1}{2}$ cm. $\times$ 5 cm. and $\frac{1}{2}$ cm. $\times$ $\frac{3}{4}$ cm. were removed from the common bile duct. Their outer surfaces were covered with a thick, well organized plastic exudate while the central portion was made up of firm organized tissues. Histologically they represent fragments of liver tissue. The central group of cells seemed viable but the outer layer was necrotic and degenerating. There was no evidence of calcification or stone formation. The tissues were impregnated with biliary pigments."

DISCUSSION

The clinical course is easily understood when all facts have been accumulated. The gallstones apparently obstructed the cystic duct, thus producing an acute hydrops. The concomitant infection, distention and vascular stasis initiated thrombosis and gangrene of the mucosal tissues with perforation of the gallbladder wall. The subhepatic abscess permitted the necrosis and fragmentation of the contiguous liver cells. Two pieces of liver tissue became detached, floated through the perforative opening into the lumen of the gallbladder, along the patent cystic ducts into the choledochus and finally lodged in the ampulla of Vater. The occlusion of the common bile duct accounted for both the jaundice and the persisting fistula.

This case clearly demonstrates the value of operative and deferred cholangiograms. The former provides an accurate pattern of

the bile ducts and clearly visualizes all types of troublesome obstructions.[2] This permits the surgeon to plan intelligently
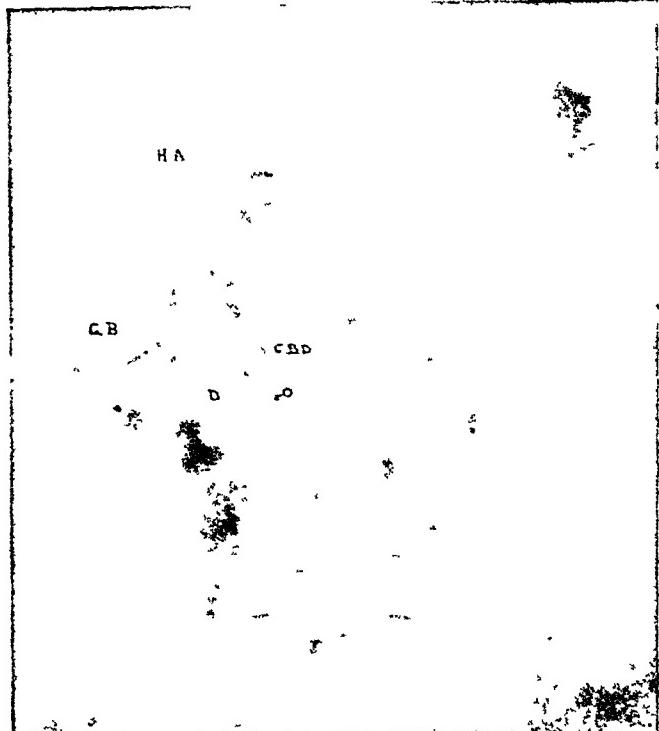
FIG. 2. Forty-five cc. of diodrast (70 per cent) were injected into the external fistula while the patient was on the operating table. The cholangiogram visualizes the gallbladder (GB), patent cystic duct (CD), subhepatic abscess (SA) dilated common bile duct (CBD), and obstructive occlusion of the ampulla of Vater (O). Note that the obstruction is incomplete as the diodrast is seen in the duodenum (D), and the jejunum (J).

corrective procedures and obviates many unnecessary ductal explorations. Every patient submitting to a cholecystostomy or choledochotomy should have a complete cholangiographic study before the drainage tubes are removed. If the ductal patterns are normal, an uneventful convalescence can be anticipated. If, however, definite obstructive lesions are recognized, the patient should be appraised of such undesirable complication and plans should be made to remove the obstruction as soon as conditions are favorable. It seems most unwise to wait for jaundice, cholangitis, pylephlebitis and hepatic insufficiency to develop before advising the secondary exploration. These undesirable complications are responsible for the high mortality rate associated with re-operations on the biliary tract.

SUMMARY

1. Following a cholecystostomy for a gangrenous gallbladder with perforation the patient developed a subhepatic ab-scess, jaundice and an external biliary fistula. Cholangiographic studies demon-strated a "filling defect" in the ampulla of Vater which produced complete chole-dochal obstruction. Two pieces of liver substance were removed from the terminal segment of the common bile duct. These detached fragments of liver apparently sloughed off from the margins of the hepatic abscess, floated through the per-forative opening into the gallbladder, through the cystic duct, into the common duct where they became impacted in the ampulla of Vater.

2. The value of operative and deferred cholangiograms in detecting endocholedo-chal obstructions is clearly demonstrated.
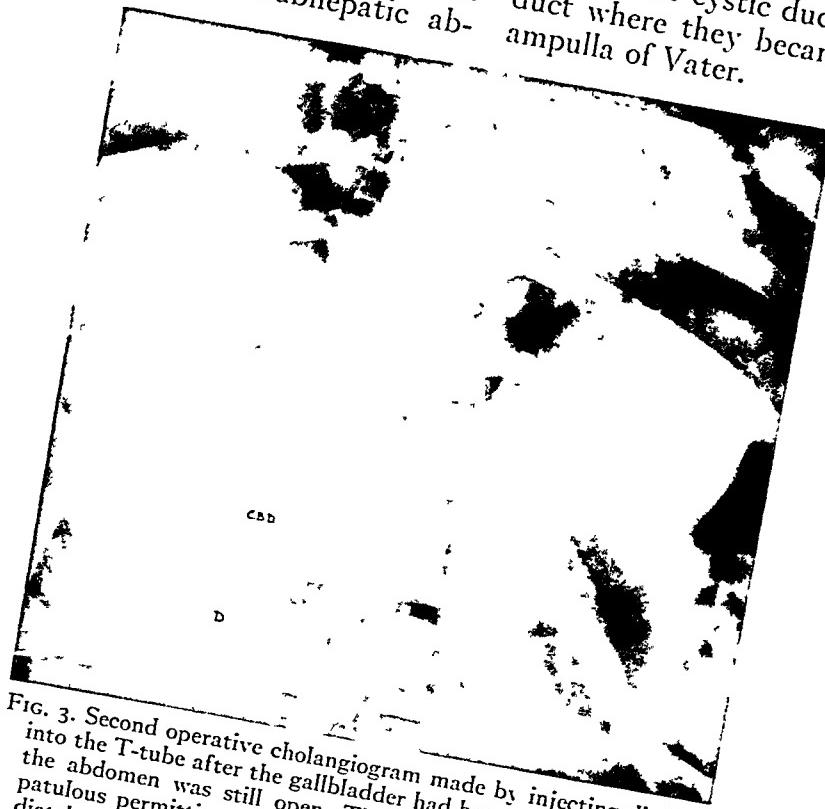
FIG. 3. Second operative cholangiogram made by injecting diodrast into the T-tube after the gallbladder had been removed and while the abdomen was still open. The extrahepatic bile ducts were patulous permitting the diodrast to enter the duodenum imme-diately (D). The ampullic obstruction which consisted of two de-tached pieces of liver had been removed.

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SUBCUTANEOUS RUPTURE OF MECKEL'S DIVERTICULUM

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SUBCUTANEOUS rupture of the bowel by blunt force is not an unusual occurrence, but rupture of a Meckel's diverticulum under similar conditions is very rare. A fairly complete search of the literature over the past twenty years does not yield a report of a single incidence.

Subcutaneous rupture of the bowel can occur in three ways: Moty's classification, which has been generally adopted, is first by crushing, second intestines are torn and third the intestines may be burst by pressure within its lumen. This force may be by direct or indirect violence or by muscular action. Direct violence is well illustrated by the kick of a horse, the jabbing of a plow handle, the sudden striking of a blow by a piece of timber or the crushing incident to being run over by a car. That by indirect violence is more often by a fall in which there is more direct trauma to the abdomen, and secondly and least frequent is occurrence by the sudden compression of a loop of bowel filled with gas. While most writers seem to think that this is relatively rare, we believe that if one takes into consideration the laws of physics, this is an element which plays a most important rôle in the majority of ruptures.

The stomach and large bowel are comparatively immune to injury, no doubt on account of their being in a protected location. Most ruptures occur in the small bowel and are said to be near some point of fixation. However, our observation in six cases has been that they occur in a fairly mobile section of the intestine. It is a fact that they are usually in the ileum or the jejunum which is explained by these points of the gastrointestinal tract occupying a fairly uniform relation to either the spine or promontory of the sacrum, and that in either instance the bowel is crushed between the force and the spinal column or the promontory of the sacrum. The direction of the trauma has also a good deal to do with the nature of the injury to the bowel and the portion of the intestinal tract involved. In other words, a direct blow impinging the bowel from a fixed point is fairly uniform in affecting either the lower ileum or the jejunum, while an injury from an oblique force will be determined mainly by the direction of the force and the obstacles which it encounters.

The danger zone of the abdomen lies in the exposed region between the symphysis and the costal margin in that here there is no protection except for the soft parts of the abdominal wall, and most injuries of this character occur in this region.

Ordinarily, there is a history of an injury, the presence of pain, shock, muscular rigidity, nausea with some vomiting and, the most diagnostic of all is the presence of free air in the peritoneal cavity as demonstrated by the x-ray. Later there is an increase in the leukocyte count, abdominal distention and those symptoms incident to a progressive peritonitis.

The mortality rate is high, some place it as high as 75 per cent to 80 per cent. This is due mainly to the delay in recognition of the pathology present. Sometimes it seems as if all factors conspire against an early recognition of such an injury. First, there is usually the delay in seeking medical advice; later there is a further delay in attempting to evaluate properly the symptoms to reach a correct diagnosis.

Treatment. The first procedure is to combat shock, and secondly, early operation is the one most important factor in treating these patients. If one waits for the development of symptoms, a general peritonitis and death are almost certain

sequelae; therefore, if there is any doubt as to whether or not there is an intra-abdominal lesion present, we have come to the definite conclusion that an exploratory laparotomy is imperative.

The case, which is the basis for this report, was that of a patient struck in the abdomen by a plow handle and it is unique from three points of view: First, the opening was only pinhole in size; secondly, it was probably due to the bursting forth of gas in the lumen of the bowel, and third it occurred in a Meckel's diverticulum.

CASE REPORT

S. A., age sixteen, healthy, while plowing was struck in the abdomen near the umbilicus with the handle of a plow at about 10 A.M. June 15th. He suffered immediate severe pain, so severe that he walked only about thirty feet and was then taken home. At 3 P.M., five hours later, he was taken to a physician who immediately referred him to the hospital where he was admitted at about 5 P.M.

Physical examination showed a well developed youth of sixteen. Heart and lungs were normal, abdomen was rigid with general soreness but he complained of the most severe pain in the right lower quadrant. He had suffered some from nausea at the outset and had vomited once. His blood count showed 16,500 leukocytes with 82 per cent polymorphonuclears. An x-ray of the abdomen was not made because of the characteristic history which would necessitate exploration.

At 6.30 P.M. a low midline incision was made and there was immediate evidence of peritonitis, the lower ileum being congested, distended and having flakes of adherent mucus upon it. There was also present a thick, dark, yellowish fluid exudate around the cecum, in the pelvis and in Morrison's pouch. The small bowel was carefully examined from the ileocecal valve to the duodenum without finding a perforation. A Meckel's diverticulum about two and one-half inches long was found about three feet from the ileocecal valve but apparently was healthy, and on account of the seriousness of the condition present it was decided to leave it alone. The large bowel and the stomach were then carefully examined throughout with still negative results. The small bowel was again gone over without finding the presence of a leak upon either the mesenteric or antimesenteric borders. The Meckel's diverticulum was again picked up and examined, firm pressure being made upon its base when there could be distinctly heard the whistle of the escaping air from a pinhole opening in its distal extremity.

The omphalomesenteric vessels were ligated, the diverticulum divided between clamps, phenolized and a running overhand suture inserted; the clamps were removed and the sutures tightened, tied and reinforced by pursestring sutures of fine linen. An enterostomy with a mushroom catheter was then made about six inches proximal to the diverticulum, the appendix was removed and a large Penrose tube introduced into the pelvis and brought out through a stab wound just above the pubis. On account of the escape of the intestinal contents into the peritoneal cavity the wound was treated by the open technic. Continuous intravenous glucose was started immediately, the patient placed upon his abdomen in bed and a therapeutic dose of antigangrene serum administered. The further course of this patient was without any untoward development.

The pathological report was as follows: The appendix is 56 mm. long. The specimen of bowel is 30 mm. long. It is a diverticulum and near the end is a little bulged part with a pin-point opening in it. Sections of the diverticulum show the distal portion congested, edematous with a rather dense polynuclear infiltration, especially just under the serosa. The mucosa is a tall villeous type with an edematous and congested stroma. There is no gastric mucosa. The appendix shows a slight congestion with only a round cell infiltration in the mucosa and submucosa. Diagnosis: Acute diverticulitis with perforation; chronic appendicitis.

THE MIGRATION OF PROJECTILES IN BLOOD VESSELS*

REPORT OF AN UNUSUAL CASE

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MANY interesting cases of migration of bullets and foreign bodies through the channels of the circulation, both arteries and veins, have been reported. To this group we wish to add an unusual instance of migration of a bullet through the arterial system.

CASE REPORT

Mr. A. M., a Filipino, twenty-six years of age, was admitted to Stanford Lane Hospital January 16, 1935. He was shot at 10:15 P.M. and seen at 10:30 P.M. The boy was rather frightened but in good physical condition. He was shot with a twenty-five calibre pistol at a distance of two yards. The patient threw his left hand and arm in front of his body to ward off the blow. Only one shot was fired. The patient fell to the floor when shot, then walked to a taxi and was brought to the hospital. Physical examination showed three bleeding puncture wounds, two in the left arm, one in the left thorax located as follows: one about one inch above the left elbow anterolaterally, one about six inches higher on the arm anteromedially, and the third in the left thorax at the level of the second rib at a line of the outer and middle third of the clavicle. There was slight bleeding but no sucking thoracic wound. The wound in the chest was clean cut, circular and showed no carbon marks. There were no motor or sensory changes in the left hand or arm. The left pulse was much weaker than the right. Examination of the chest revealed dullness and absence of breath sounds about three inches higher on the left than right back. Respirations were 30 per minute, and the pulse rate was 76. The patient had a feeling of faintness and shortness of breath. The wounds were treated with 4 per cent iodine and sealed, and the patient was sent for x-rays.

Fluoroscopic examination failed to reveal a bullet in the thorax. No fluid level was made out. A high diaphragm was seen on the left.

Fluroscopic and x-ray examination early the following morning showed the bullet to be in the left thigh just below the groin. At this time the dorsalis pedis pulse was good and there was no pain in the leg. His left leg appeared to be slightly larger than the right and felt warmer. There was no hemorrhage.

He was prepared immediately for operation. The bullet was located by x-ray before operation by means of a lead square placed on his leg. The position was marked out with acriflavin. Dr. Emile Holman was the surgeon. Under local anesthesia a skin incision about 10 cm. long, immediately over the femoral vessels, was made through the full thickness of the subcutaneous tissues. The femoral artery and vein, with their accompanying nerves, were located. These vessels were developed by blunt dissection. After some searching the bullet could be palpated in the proximal portion of the deep femoral artery about 1 cm. from its origin. Two braided silk sutures were passed about the deep femoral artery on either side of the bullet. An incision about one-third of the diameter of the vessel was made through its wall and the bullet delivered. An unsuccessful attempt was made to suture the incision in the artery. The artery was then divided, ligated and transfixed with double medium black silk. The subcutaneous tissues and skin were closed. The bullet showed no bone markings.

His postoperative course was quite uneventful. Several chest films were made and on the first postoperative day a moderate amount of fluid appeared in the left chest. Fifteen days after the operation, on discharge from the hospital, the amount of fluid at the left base had decreased to a very small amount and the diaphragm had become lower.

We have followed this patient from time to time in our Out-Patient Surgical Dispensary since his dismissal. At the present time, five and

FIG. 1. Photograph of x-ray showing bullet in the left deep femoral artery.

one-half years after the accident, he is perfectly well.

Our conclusions of the mechanism are as follows: It seems most probable that the nearly spent bullet entered directly into the subclavian artery in a well supported location and carried the adventitia into the rent. As the invaginated vessel wall came back to its normal position, the opening was closed. The weak pulse was due either to spasm of the injured vessel or to the tissues carried in. The right and left pulses were of equal strength fifteen hours after injury.

In reviewing the literature on the migration of projectiles in blood vessels, four cases were found to have been reported similar to the one presented here: de Roualt relates the case of a soldier who had been shot in the arch of the aorta; the missile dropped into the left femoral artery causing an ischemic paralysis and gangrene of the limb, followed by death. Bland-Sutton reports a case of a soldier wounded in the chest. Four pints of blood were evacuated from the chest and the wound closed. Streptococci were obtained in the culture and the man died on the fifth day. At autopsy a small wound was found in the aorta just below the arch

and the bullet embedded in firm clot in the external iliac artery. Boechel reports that a bullet, previously localized by fluoroscopic screen in the left heart, was found obstructing the femoral artery, where it caused gangrene of the limb requiring amputation. Piedelievre reports a case in which the bullet entered the chest to the right of the sternum. The patient died of a pericardial effusion. At autopsy the bullet was found in the left femoral artery at its bifurcation, having pierced the superior portion of the pericardium and then entering the aorta.

Many interesting cases of the migration of projectiles in the heart and blood vessels are summarized in Keen's Surgery. There are several papers discussing the experimental evidence of the varied migration of shot, rice, and other foreign bodies introduced into the arteries and veins, as a result of their migration into the heart and lungs, as well as studies of the weight and size of the foreign body, force of gravity and of posture. Experimental workers in this field have proved that under ideal circumstances bullets can be made to enter the lumen of a rubber tube, in which a water pressure has been established equal to the blood pressure in the aorta, after penetrating only one wall, as long as this tube is supported posteriorly. They have shown that gravity, posture, the specific gravity of the foreign body and the blood flow are all factors in the direction of the migration within the vessel. These result in rather remarkable and, in some instances, incredible migrations of the foreign body from the original site of injury, causing one to wonder how the victims survived their wounds.

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MULTIPLE SHELL WOUNDS

A CASE REPORT

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THE case report which follows presents several points of interest. The injuries caused by a shell explosion are similar to war wounds; the extent to which fluids were forced is somewhat unusual; the successful prevention of infection in the multiple wounds contributed materially to the outcome and the loss of blood type during the course of treatment introduced a very troublesome factor.

CASE REPORT

The patient was a well developed, muscular, white male, age thirty-five. He was admitted to the emergency room of St. Peter's Hospital, New Brunswick, New Jersey, December 27, 1939. The injuries were due to the explosion of an artillery shell which was actually in his hands at the time of detonation. On admission the patient was conscious, but in extreme pain and morphine sulfate gr. ¼ was administered liberally. Superficial examination revealed an almost complete traumatic amputation of the left hand and right foot and a compound comminuted fracture of the right tibia. The skin, subcutaneous fat and superficial musculature of both thighs medially, from knees to the perineum, had been torn away. The scrotum had been partially torn away and the remainder suffered a second degree burn. A gaping wound was visible adjacent to the anal orifice. The face was lacerated and burned as well as the eyebrows, eyelashes and hair over the frontal area. A tourniquet was immediately applied to the right leg and a sphygmomanometer cuff placed around the left arm. Blood pressure was exceptionally good (100/50) and pulse rapid (140) but of good quality.

Immediate treatment included application of external heat, administration of combined tetanus and gas gangrene antitoxin. Glucose 50 per cent (50 cc.) was given intravenously followed by a venocysis of 10 per cent glucose in saline. Visible bleeders were ligated and wounds irrigated with lavish amounts of preheated saline. Copious saline-soaked dressings were applied and the patient admitted to the surgical service of Dr. James L. Fagan. Shortly after admission 500 cc. of citrated whole blood was given.

After four hours dressings showed an appalling amount of oozing. The pulse had lost its initial quality, respirations were labored and blood pressure had fallen to 80/40. The Trendelenburg position was increased and both adrenalin and caffine sodium benzoate administered. Venoclysis of glucose in saline was repeated.

An additional four hours (eight after admission) warranted another half liter transfusion, which was followed by a severe chill. Sodium bicarbonate orally was used to forestall renal block. In two hours 16 ounces of clear urine, (microscopically) voided spontaneously dispelled our anxiety. Surgery was deferred due to the condition of the patient.

The following morning the right leg was amputated at the junction of the proximal and middle thirds employing light cyclopropane anesthesia. The left hand was amputated at the wrist. The medial thigh wounds were débrided and the patient returned to his room in a fair condition.

The forcing of fluids was continued and four hours postoperatively the patient spontaneously voided 26 ounces (780 cc.) of urine. Computation of twenty-four hour fluids revealed a total intake of 11,270 cc., viz 50 cc. of 50 per cent glucose, 1,020 cc. of citrated whole blood, 1,500 cc. of 5 per cent glucose, 5,300 cc. of normal saline and 345 cc. of liquids orally. This wholesale administration of fluids is not presented as a routine method of therapy, for the disastrous results to a weakened myocardium or damaged glomerular system can readily be appreciated. However, having been given ample evidence of a well functioning cardiorenal system we felt justified in pushing fluids as we did.

On the first postoperative day forcing of fluids was continued. The patient's temperature

rose steadily and there was evidence of weakness. An additional transfusion was given, but the laboratory advised that instead of the usual clear cut typing, a slight agglutination occurred when cross-matched. A severe chill followed shortly after transfusion. The chills ceased after administration of 1 ampule of amyl nitrate per inhalation and nitroglycerin sublingually. At this time the patient became violently irrational. His temperature rose to 106°F. axillary (which was twice checked) pulse 144 and respirations to 136.

On the second day removal of dressings disclosed a thick discharge from the thigh wounds. This was extremely malodorous. Copious quantities of hydrogen peroxide were used for cleansing. The wounds were dressed with azochloramid-soaked compresses in which were incorporated five-tube Dakin tubes. The scrotum was supported with wide adhesive strips (Bellevue Bridge) and was also dressed with azochloramid compresses as was the pararectal wound. The nursing staff was instructed to instill the solution into the Dakin tubes twice daily and soak all other dressings with azochloramid. On the face, application of sterile vaseline were adequate.

During the second twenty-four hours the patient received a total of 8,890 cc. of fluids. Urinalysis at this time was essentially negative.

An additional transfusion was contemplated but all previous type specific donors failed to cross-match and showed a dangerous amount of agglutination. The recipient was retyped and it was discovered that he was no longer Type IV (Moss); in fact, his blood no longer fell into any specific type. The apparent change of type was probably a loss of specificity and transfusion had to be deferred because of this complicating factor.

Smears indicated the presence of both staphlococci and streptococci in the various wounds and these findings were confirmed in cultures. Sulfanilamide (gr. 15) was administered every four hours. That night the patient became irrational and tore off all dressings. Sodium luminal intramuscularly was given to avoid self-injury. On the sixth postoperative day it was necessary to use restraints to control the patient. Believing that absorption of large quantities of toxic material might explain this behavior, further transfusion was advised despite imperfect cross-matching. One-half liter of whole blood was administered and despite several chills general improvement

followed. Within twenty-four hours the patient cleared up mentally; he was able to take a soft diet and for the first time had a spontaneous bowel movement.

The administration of sulfanilamide was discontinued after ingestion of 540 gr. to avoid deleterious hemopoietic retardation. A blood count warranted our action. Hemoglobin had been reduced to 35 per cent, erythrocytes 2.13 million, leukocytes 19,300 with marked left shift. Other blood findings indicated evidence of achromia, polychromasia, anisocytosis and poikilocytosis.

In view of the difficulty with transfusion, iron medication by mouth was instituted, supplemented by liver extract as well as vitamins B_1 and G. By the twenty-sixth day all wounds were gratifyingly clean and the thigh wounds appeared ready for grafting. Despite this the patient's temperature began rising and an abscessed area was discovered in the gluteal region. Using Hilton's technic the area was drained and 1200 cc. of purulent material expressed. Uterine packing soaked in azochloramid was employed and the skin margins protected by zinc oxide ointment. On the thirtieth day the blood picture showed sufficient improvement to permit extraction of several teeth which had been broken by the impact of the explosion. By the fortieth day the need for further transfusion became imperative and to our gratification cross-matching was again possible. The patient's condition had improved to the point at which massage and passive exercise were possible by the one hundred and fortieth day. All wounds had healed completely with the exception of the right leg stump. One hundred and seventy days after admission he was discharged to the Out-Patient Department for fitting of artificial limb and minor dressings.

SUMMARY

Despite an exceedingly poor prognosis, the ability of the patient to tolerate high fluid intake plus the early control of infection in the wounds due to the employment of azochloramid preparations contributed to a successful outcome.

Loss of blood type while the patient was under treatment proved a troublesome factor which was partially offset by the administration of iron, liver extract and vitamins B_1 and G.

AVULSION OF THE DISTAL TENDON OF THE BICEPS BRACHII

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AVULSION of the distal tendon of the biceps brachii is sufficiently rare to warrant the reporting of each new case. It is far less common than rupture of the tendon of the long head of the biceps. As late as 1931 Platt[15] writing on tendon ruptures in general, was unable to find any record of such a case in surgical literature. Yet Gilcreest[5] made an exhaustive review of the literature, including foreign journals, in 1934 and collected nineteen cases which included rupture and avulsion. To these he added three, one being his own. Since then I have found six additional cases in the American literature in which the distal tendon of the biceps brachii was either ruptured or avulsed. Waugh[20] had two patients with a rupture of the distal tendon, one of which was proximal to the lacertus fibrosus. Since the other patient was not operated upon, it is indefinite as to whether it was a rupture or avulsion. This is mentioned especially because it has been stated in a standard surgical textbook that when the tendon of insertion ruptures it is always a true avulsion. Few textbooks make mention of the lesion at all.

The question of whether or not there was a co-existing pathological condition of the tendon usually arises in injuries of this nature. No cause was found in the literature, but it seems probable that the stress of the muscle contraction is too great for the structures concerned and some point has to give way. Necessarily, there would not have to be pre-existing pathologic changes. However, Donhauser and Kenny[4] reported a case in which there was active inflammation and purulent exudate surrounding the insertion of the biceps tendon. McMaster[11] proved in a series of well controlled experiments on young, healthy rabbits that normal tendons do not rupture. Either the muscle will rupture or the tendon attachment will pull apart.

The diagnosis of avulsion of the distal tendon of the biceps brachii should not be difficult. It nearly always occurs in men over forty. The history is similar to that of tendon ruptures in general. That is, during muscular exertion a sudden snap is heard and felt, simultaneously, with attendant sharp pain located in front of the elbow soon becoming constant and dull. Weakness of the upper arm is immediately noted. The examination usually reveals ecchymosis over the antecubital fossa, the degree of which depends upon the amount of time that has elapsed following the injury. This may extend several centimeters proximal and distal to the elbow. The patient can flex and rotate his forearm but a definite weakness is noted, coupled with a soft bulge in the proximal half of the upper arm. The distal tendon can not be palpated.

Treatment consists of operation as soon as possible. Since little has been written on this condition, the surgeon generally has no precedent to follow and must rely on his own ingenuity. Numerous methods have been employed for reattachment of the tendon. Platt[15] passed the tendon through a hole perforating the radius and sutured it to itself. While making a strong union, it does not necessarily re-establish the original supinating power of the biceps. Sonnenschein[18] raised a trap door in the radius and placed the end of the tendon therein. Gilcreest[5] mentioned two methods; first, Kerschner's, in which the tendon was fixed to the radius with a nail.

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Secondly, if this were not possible, he advised suturing it to the neighboring soft structures. Waugh[21] stated that fascial transplant fixation through drill holes in the radius was probably the best method. Rogers[12] used double, heavy braided silk passed through drill holes in the radius and mattressed it in the end of the tendon. Leavitt and Clements[9] scarified the bicipital tuberosity, drilling two holes in the medial projecting margin. Then they inserted heavy silk through one hole and four strands of No. 2-40 day chromic catgut in the other. These were woven into the tendon, pulling it flat against the scarified tuberosity. Bauman[1] made a small incision in back of the upper part of the forearm through which he passed No. 3 plain catgut. The end of the tendon was sutured with one end and the other tied over a gauze pad in back of the forearm. This pulled the tendon down on the radius. Donhauser and Kenny[4] due to acute inflammation in this region, sutured tendon to the antebrachial fascia 3.5 cm. distal to the elbow. They obtained a satisfactory result but do not advise this method in the absence of infection. Another method that has been mentioned is suturing the tendon to the brachialis tendon just before its insertion into the ulna. The lacertus fibrosus should also be sutured. Postoperatively, the arm is put up in flexion and partial supination. The length of time before beginning motion of the elbow varied from two to six weeks in the cases previously reported.

Full function is usually obtained in about two to three months. There is sometimes mild discomfort in the elbow and five to ten degrees limitation of extension. The results seem to be uniformly good regardless of the technic employed.

CASE REPORT

L. Q., a white man, aged forty-two, was admitted to the hospital on the evening of February 5, 1941, complaining of pain in the right arm. His past history was interesting in that he had been accustomed to heavy work all his life, having been a foundry worker until about six months prior to admission. He gave the following history:

FIG. 1. Appearance of the right arm prior to repair of the avulsed tendon.

About 9 A.M. February 4, 1941, with his right hand he picked up a scuttle of coal weighing between fifty to seventy pounds. As he flexed his forearm to an angle of about 100 degrees he felt a sudden sharp pain in front of the elbow, simultaneously hearing a noise similar to that when a piece of gauze is torn. There was immediate weakness of his arm and pain radiating from the middle of the forearm to the shoulder. His forearm gradually extended because he was unable to release his grip on the scuttle. The immediate pain was followed by soreness throughout the arm. At 6 P.M. the following day he was sent by his physician to the hospital with a diagnosis of "strained ligament, severe." At this time his symptoms were soreness and weakness of the right arm.

His general physical examination was essentially normal except for obesity. His height was sixty-six inches and he weighed 197 pounds, unclothed. Blood Kline and Mazinni reactions were negative. Inspection of the right arm revealed ecchymosis on the anterior surface from just beneath the antecubital fossa to the junction of the middle and upper third of upper arm. There was tenderness over the usual course and attachment of the distal tendon of the biceps brachii. On contracting the biceps a large, soft lump formed in the proximal half of the upper arm and the distal tendon could not be palpated. (Fig. 1.)

A diagnosis was made of avulsion or rupture of the distal tendon of the biceps brachii, and on February 7, 1941, an operation was performed under inhalation anesthesia. A midline

incision was made on the anterior surface of the upper arm from the middle to about two inches above the antecubital fossa. On incising the

tuberosity was exposed, revealing that the periosteum was stripped from the bone and frayed for a short distance. The synovial bursa
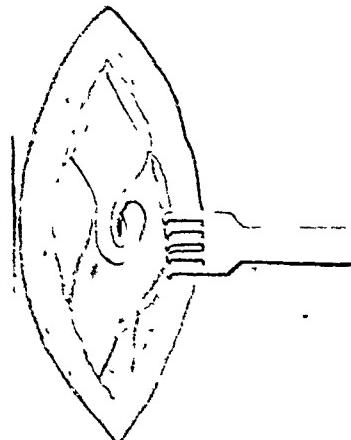
FIG. 2.   FIG. 3.

FIG. 2. Diagram showing the position of the tendon as found at operation.
FIG. 3. Diagram showing position of tendon after attachment to the bicipital tuberosity.
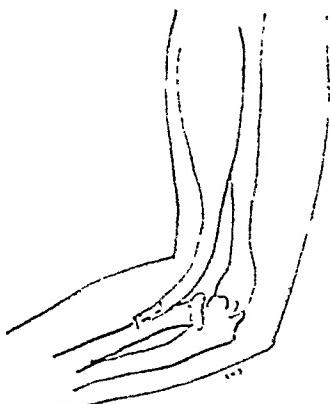
FIG. 4. Photograph of patient seven weeks postoperatively showing normal contour of right arm.

brachial fascia a moderate amount of recently extravasated blood escaped. The fascial incision was lengthened and lying beneath this in the upper part of the wound was the distal tendon of the biceps brachii. (Fig. 2.) The tendon was coiled upon itself, the end being smooth and bulbous with a small hematoma on the surface of attachment. The lacertus fibrosus was torn and frayed.

Of necessity the incision was extended into the upper part of the forearm. The median basilic vein, branches of the recurrent radial artery and anastomosing branches of the brachial vein were ligated allowing retraction of the median nerve, brachial artery and veins medially. Then the pronator teres was retracted medially and by blunt dissection the bicipital

was not found. Due to the man's obesity the wound was quite deep. A drill hole was placed into the bicipital tuberosity on each side after the forearm had been fully supinated. The tuberosity was then roughened with a small osteotome. Then a strand of No. 2-40 day chromic catgut was inserted through the bone and passed through the tendon, whose surface of attachment had first been freshened, in such a way that it was pulled tight. The neighboring soft tissues were sutured to the end of the tendon with No. 0 chromic catgut. The latter part of the procedure had to be performed with the forearm flexed to about 95 to 105 degrees in order to relieve tension on the sutures, which, along with the depth of the wound, made working tedious. An attempt was made to repair the

lacertus fibrosus but it was so badly torn the sutures would not hold. The wound was closed, using catgut for the brachial fascia and interrupted vertical mattress sutures of dermal for the skin.   ·

The arm was fixed in acute flexion at the elbow with a posterior plaster splint and taped to the chest. Active motion of wrist was started on the second postoperative day. On the twelfth postoperative day the tape was removed and skin sutures taken out. The wound had healed by first intention. Using a metal splint, the arm was then fixed in ninety degrees flexion and active motion of shoulder was begun. On the twenty-ninth postoperative day the metal splint was removed and a sling used. Active rotation of forearm along with the shoulder motion was encouraged. During the fifth week, infra-red, massage and passive motion was started along with weak galvanic stimulation of the biceps. By the end of the sixth week, post-operatively, there was normal motion of the shoulder with less than five degrees limitation of extension at the elbow. There was no visible atrophy. On contraction of the biceps the distal tendon was definitely palpable as a tense cord in the antecubital fossa. The patient was able to use the arm freely except for heavy lifting and complained of no discomfort. Figure 4 shows a photograph taken seven weeks postoperatively.

SUMMARY

1. Avulsion of the distal tendon of the biceps brachii is a rare injury.

2. The various methods of repair are briefly mentioned.

3. The method of simple attachment to the radius gives good results.

4. A new case is reported.

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PSEUDOFRACTURE OF THE TIBIA

REPORT OF TWO CASES

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IN 1939, Roberts and Vogt[1] first called the attention of the medical profession to an unusual type of lesion occurring in the upper third of the tibia and sometimes found to be bilateral. Because the lesion resembled an incomplete fracture line with periosteal bone proliferation, the disease entity was called "pseudofracture of the tibia." Both of these authors realized that in spite of the appearance of a fracture-like line, trauma *per se* was not the cause of the lesion, but rather that some low grade inflammatory process, influenced by the vascular pattern of the nutrient vessels, and abetted by physiologic trauma and strain, were more pertinent factors in the development of this lesion.

Weaver and Francisco,[2] in 1940, added three cases of their own to the twelve collected by Roberts and Vogt, making a total of fifteen cases reported. Their cases showed that the condition can occur in the older age group, thus widening the reported age incidence of from four to sixteen years to four to twenty-three years. It has also been demonstrated by the later authors that this very same lesion can occur in other bones. Specifically described were the upper and lower ends of the fibula of one individual. However, no matter which bones are involved the sites are comparable, being located at the junction of the infundibulum of the metaphysis and the diaphyseal shaft.

An allied condition is the "march fracture" which occurs in the shaft of the second or third metatarsal and is intimately associated with weak, relaxed feet and constant low grade trauma. Ollonqvist,[3] of Finland, reports a series of cases resembling pseudofracture of the tibia occurring in young army recruits. Weaver's cases would fall into this age group. In 1938, Looser[4] described a pathological condition of bone in which a rarefaction zone developed in or near the metaphysis followed by bone hyperplasia. From his description the term, "umbauzone," or "Looser's rarefaction zones," was coined. Two cases not presented in this article have been observed by the authors in which pseudofractures have developed in the upper tibia, of osteomyelitic bone following radical surgery of that bone. In both cases the absence of a normal marrow cavity and the poor bleeding quality of the bone evidenced the fact that the circulation was impaired.

The pathological report of four known biopsies showed varying degrees of a low grade inflammatory process consisting of perivascular mononuclear cell infiltration, fibrillar connective tissue displacement of the marrow and comparatively normal bone trabeculations.

The clinical importance of this disease entity is that the condition is often confused with a traumatic fracture, Ewing's sarcoma or osteomyelitis. The original authors dwelt at length on the differential diagnosis of traumatic fracture from pseudofracture because traumatic fracture was then the usual roentgenological report.

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The pathological examination, however, invariably reported that the biopsy was of low grade inflammatory tissue. In the

aggravated by use and relieved by rest, which fact differentiates the condition from bone tumor, in which the pain may

FIG. 1. A, showing area of lessened density and deposition of subperiosteal bone. B, localized sclerosis and subperiosteal deposits of bone producing the "peak phenomenon" on the medial and posterior surfaces.

FIG. 2. A, development of pseudofracture line. B, the pseudofracture extends from the bone periphery through the callus.

two cases presented the diagnosis was that of Ewing's sarcoma in the first, and osteomyelitis in the second, until further studies proved the cases to be pseudofractures. Irradiation therapy was being considered on one hand, and the Orr method of saucerization and open packing was considered as treatment for the other and would no doubt have been carried through just a few years ago.

In reviewing the clinical features we find that a history of slight injury to the area may or may not be present. At the onset there is usually a low grade fever accompanied by pain in the tibia about three inches below the tibial tubercle. The fever soon subsides and the patient is generally not so acutely ill as in osteomyelitis, or not ill at all. The pain is

be present at any time and even while at rest. The local examination shows that the pain area is precisely demarcated to a spot about three inches below the tibial tubercle. A small amount of localized edema and periosteal thickening can be made out, but usually the signs of abscess formation are lacking. Laboratory tests are not specific enough in their results to aid in the diagnosis. The diagnosis and differential are made mainly upon roentgenological studies. (Figs. 1, 2, and 3.)

X-RAY REPORT

The roentgenological studies show in the earliest cases a circumscribed area of lessened density at the junction of the upper and middle thirds of the tibia, central in location in reference to the diameter

of the shaft, and at a point three and one-half inches below the knee joint line. There is no soft tissue swelling and there is no

which is the most characteristic feature of this condition, is a late progressive phenomenon, and it extends through the new
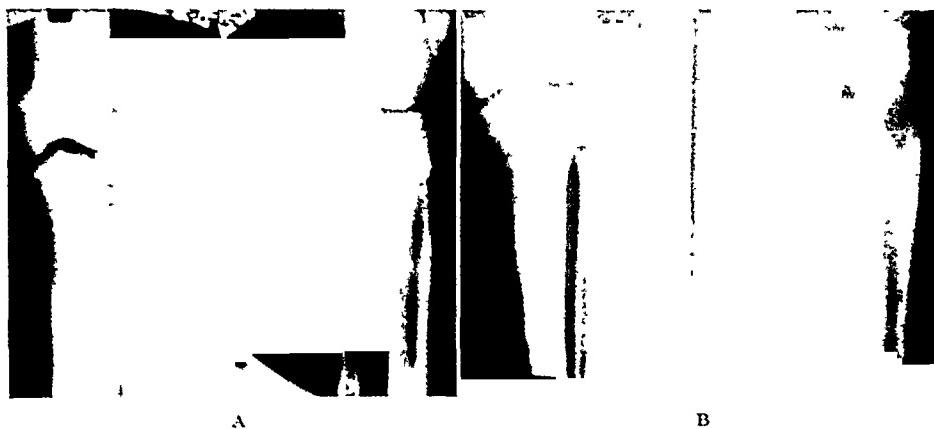
Fig. 3. A, disappearance of pseudofracture line and smoothening out of the callus. B, the pseudofracture is disappearing and the sclerosis is being dissipated.

generalized osteoporosis. The rarefied area soon changes to one of localized sclerosis. The sclerosis is characteristic in that it is distributed transversely across the diameter of the shaft. It is about three-fourths of an inch wide, shows several short crisscrossed lines of rarefaction and the presence of new subperiosteal bone. The new bone is most prominent at the posterior aspect of the tibia, at which point it produces a definite "peak." There is only a very slight amount of new subperiosteal bone on the anterior surface. The medial surface also shows the increased periosteal bone with the "peak phenomenon" and a rather smooth deposition of bone on the lateral interosseous surface. As the condition heals, the subperiosteal deposits of new bone become distributed in a more uniform and fusiform manner, replacing the "peak phenomenon" seen earlier in the disease. The fact that most of the new bone is laid down on the posterior and medial surfaces would indicate that bone proliferation in this condition follows the line of greatest stress and strain to which the tibia is subjected. Subsequent pictures show that the area of sclerosis becomes narrowed down and a transverse, fracture-like line begins to make its appearance, developing at the periphery and approaching the center. This fracture-like line,

subperiosteal bone as seen in different x-ray views. The line differs from a true traumatic fracture in that it develops as a progressive phenomenon, and it extends through the new bone deposits in contradistinction to a true fracture line, which stops at the callus.

Ewing's sarcoma in the earliest stages may give a similar picture because of the identical location and the laminated onion-peel deposits of subperiosteal bone. However, Codman's triangle as usually seen in malignant tumors is not characteristic in such conditions as pseudofracture of the tibia. The subperiosteal "peak phenomenon" and the presence of the pseudofracture line should clearly differentiate the two conditions.

CASE REPORTS

Case 1. D. C., male, aged twelve years, developed sudden pain in the right upper leg. The pain was of a continuous character at the onset and moderate fever was present for one week. There was no history of injury, chills, sore throat or furunculosis. Weight loss or pains in other bones were not present. The pain became dull and low grade in character and was later present only on weight bearing and activity. Three months after onset the patient was admitted to the hospital, where an examination showed a well nourished boy not acutely ill.

The physical examination was negative except for the right leg.

The right leg showed a very slight palpable swelling on the inner aspect of the right tibia just three inches below the tibial tubercle. There was no local heat nor redness, no contracture of the ham-strings, no swelling nor edema of the lower leg, and the veins were not prominent. The painful zone was sharply circumscribed and pain was elicited on percussion and light pressure.

The laboratory work showed a normal blood sedimentation rate, a normal white and red count and normal differential. The urine and Wassermann tests were negative. The blood culture and agglutination tests for undulant fever and the typhoid group were negative.

The patient was immobilized in a plaster cast with immediate relief and made an uneventful recovery. Duration of the convalescence was six months.

Case ii.   E. P. The patient was an active, healthy girl of thirteen years who fell on the ice in February, sustaining only a slight abrasion of the shin. The patient continued her activity without any complaints until one month later, when she started to limp and complain of pain in the upper leg below the knee. There was no acute febrile attack at any time. The ache was recurrent on activity but never severe enough to confine her to bed. About four months after the original injury a "bump" the size of a quarter was noticed over the shin about three and one-half inches below the knee joint. The swelling and tenderness were fairly well circumscribed, but there was no redness or fluctuation. The patient was seen by several consultants who at first advanced the diagnosis of either Ewing's sarcoma or muscle stress fracture, until time brought out the true

diagnosis. The ache and limp subsided with prolonged rest over a period of a six months convalescence. The "bump" on the shin still remains, but the x-ray picture shows complete healing with the disappearance of the fracture-like line.

SUMMARY AND CONCLUSION

The importance of this condition lies in the differential diagnosis rather than in the morbidity of the disease itself. Needless to say, traumatic fracture (because of its medicolegal aspect), Ewing's *sarcoma* and *osteomyelitis are the main* confusing entities that must be completely ruled out. All cases reported recovered with or without treatment. The treatment resolves itself into conservatism and rest of the part; and because one case has been reported by Roberts and Vogt in which a pathological fracture occurred during excessive use, a splint or a plaster cast for eight to twelve weeks and bed rest during the acute phase are recommended. The convalescent period for both cases was six months. A recurrence of pain was noted in Case i, following too early return to activity. Resumption of cast immobilization produced a clinical cure in six months.

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RECURRING PYOGENIC OSTEOMYELITIS

REPORT OF A CASE WITH A FORTY-SEVEN YEAR QUIESCENT PERIOD BETWEEN ATTACKS

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IT is generally understood that pyogenic osteomyelitis, after it has reached the chronic stage, may drain either continuously or intermittently for many years with relatively short periods of quiescence between exacerbations. That this disease might run through the acute to the chronic phases within a period of months and then lie dormant for years only to become active again is not well appreciated. The following case is of interest because it points out the potential danger of active recurrence of pyogenic osteomyelitis many decades after the subsidence of all clinical symptoms.

CASE REPORT

The patient is a white male, age fifty-six, a native of Latvia, Russia. At the age of nine years both feet and legs were frost bitten while sleigh riding. Both legs became infected, and about three months after the onset he was sent to a clinic where the legs were operated upon. The patient claims that "the bones (tibiae) were scraped." The wounds drained for approximately five or six months following operation and then healed.

He had no further trouble until the age of thirty when, while ice-skating, he fell and bruised the right tibia. The leg began to ache and swell, necessitating the application of moist hot packs. Three weeks after the injury drainage occurred spontaneously and lasted for two or three weeks. Since the age of thirty the right leg has ached occasionally unassociated with trauma. There have been times since the age of fifty when the soreness has been more pronounced. At such times poultices were used to localize the inflammation, evoking spontaneous evacuation of the pus which drained for a day or two.

The left leg was entirely symptom-free until December 2, 1939, forty-seven years after

healing of the original focus in the tibia. On this date the left tibia sustained a sharp blow by a heavy ruler. Although the patient experienced immediate pain at the point of impact, he continued to work, the pain subsiding within an hour. Swelling and ecchymosis were noted at the site of trauma the same evening. On December 3, the leg began to ache. The pain increased gradually in intensity until sleep was interfered with. Moist hot packs afforded temporary relief.

Although he had lost thirty pounds due to lack of sleep since the onset of the present illness, his general health was good. The past history was essentially negative; he stated that, other than the trouble with his legs, he "never had a sick day in his life."

Physical examination on January 3, 1940, revealed the circumference of the left leg just above the malleoli to be 1 cm. more than the right. Three scars over the anteromesial aspect of the distal third of the left leg were noted. Increased local elevation of temperature was evident. This region was very tender, but no areas of fluctuation were palpable. The ankle motion was free. There were numerous large varicose veins of the entire leg. Left inguinal adenopathy was present.

There were several scars along the anteromesial aspect of the right leg at the middle and lower thirds. Palpation did not reveal any tender areas or increased local heat. Large varicose veins were noted.

The laboratory data showed a sedimentation rate of 31 mm. the first hour. The red count was normal. The total leucocyte count was 14,550 with 48 per cent adult and 4 per cent band polymorphonuclears. The Kahn reaction was negative.

Roentgenographic examination of both legs was made on December 22, 1939, and repeated on January 17, 1940. The anteroposterior view of the left tibia revealed a club-like thickening of the distal half. (Fig. 1.) The cortex in this

region was thickened and very irregular. About one and one-half inches from the distal articulation a well demarcated shadow representing

FIG. 1. Anteroposterior and lateral views of the left tibia showing the abscess cavity and the thickening of the distal half.

an abscess cavity was seen. The bone surrounding the cavity appeared very dense. The abscess was even more plainly visible on the lateral view. (Fig. 1.) The rarefied area measured one and one-half by one and one-fourth inches. The cortex in this region seemed intact. The medullary canal was almost obliterated in the distal half. The ankle joint was clear.

The anteroposterior view of the right tibia revealed a similar club-like appearance of the distal half. (Fig. 2.) The cortex in this region was likewise thickened and irregular. Although a suggestive mottling was seen, especially in the lateral view (Fig. 2.), there was no definite abscess cavity. The ankle joint was negative.

A diagnosis of reactivation of an old, quiescent, osteomyelitic focus of the left tibia was made. Conservative treatment was carried out at home for ten days without alleviation of the

symptoms, during which time a slight fever was recorded. Operative interference was then advised, and the patient was hospitalized.
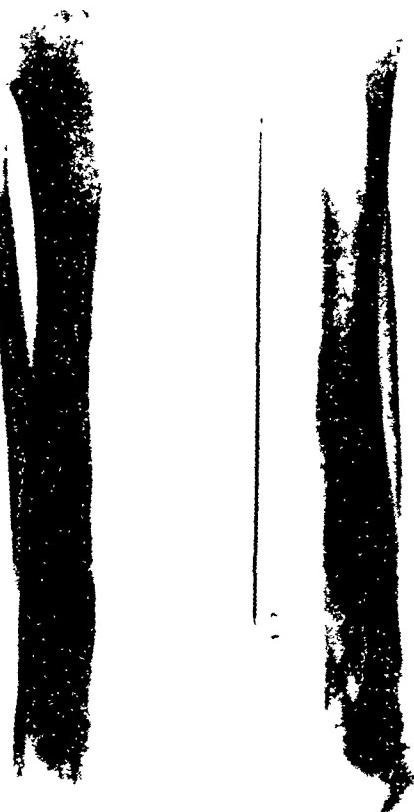
FIG. 2. Anteroposterior and lateral views of the right tibia. Note the increase in width of the distal half with obliteration of the medullary canal.

On January 18, 1940, under ether anesthesia the left tibia was exposed. A small hole was found in the cortex through which pus welled out as though it were under increased pressure. A culture was taken. A window was made in the cortex, revealing an abscess cavity approximately two and one-half inches in length, the walls of which were very thick and eburnated. The cavity itself was filled with light greenish-yellow, thick, gelatinous pus. The lateral wall of the cavity was eroded entirely through the tibia. The abscess was completely unroofed and packed with vaseline gauze. A plaster cast from midthigh to the toes was applied.

A direct smear of the pus taken at operation showed two small clumps of Gram-positive cocci. The twenty-four-hour culture revealed no growth. After forty-eight hours a pure culture of Staphylococcus albus was obtained. Repeated cultures verified this result.

COMMENT

The findings in this case indicate that the osteomyelitic focus in the left tibia was a sequella of the original inflammation forty-seven years previous to the present attack. The marked eburnation of the abscess wall, the gelatine-like quality of the pus, the sparcity of organisms on direct smear and their attenuation, requiring forty-eight hours for growth on appropriate culture media, would seem to verify this opinion.

Phemister[1] believes that foci of osteomyelitis may be silent not only in the development of the lesion but also to the stage of complete bony destruction before any local symptoms become manifest. If the lesion is a recurrence in a previous site of osteomyelitis, general symptoms of infection may be present even though the local lesion is silent. He explains the silence of the lesion as being due in part to the low grade of the inflammatory process which may be the result of attenuation of microorganisms or of an increase in body resistance in the course of prolonged infection. The reported case shows that osteomyelitic foci can and do remain silent over a period of a lifetime, awaiting only proper stimuli and conditions of the host to reawaken into clinical activity.

Breck[2] recorded a case of chronic osteomyelitis in which there was an interval of fifty years between operations. This patient had recurring mild attacks of pain and swelling which lasted for several days throughout the entire intervening period. There was no mention of drainage associated with the attacks. The author's case differs from Breck's in that there were no symptoms referable to the left leg during the forty-seven years.

Although the factor of trauma is problematical at best in certain cases of pyogenic osteomyelitis, there is little doubt that the realighting of the disease in this instance was directly attributable to the blow struck by the ruler. The cause and effect appear to be intimately related.

SUMMARY

A case of pyogenic osteomyelitis of the left tibia, erupting after a forty-seven-year interval of quiescence, is presented. It illustrates that this disease may be an ever-present sword of Damocles to a patient, and that an apparently well healed lesion may become active under proper conditions.

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ADENOMA OF LANGERHANS' ISLET OF THE PANCREAS*

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REPORT OF CASE

M. H. H., age sixty, had had periods of mental confusion, difficulty in walking and loss of stature. The patient had been under treatment in another city for chronic arthritis. Vaccines and diathermy had been administered during the last three years, in spite of which walking had become more and more difficult. The patient's family had noticed that she was not as tall as she used to be.

In September 1939, while talking with a friend on the telephone, she became incoherent, her voice weakened and ceased altogether. Two hours later, her son found her with the telephone receiver in her hand and in a stuporous condition. A cup of hot tea was given, after which she recovered quickly. She remembered a sense of weakness coming over her while she was phoning. A month later a similar attack occurred during which she laughed and cried alternately, perspired freely and made uncoordinated movements of the arms and legs. Hot tea was again given and she recovered promptly. Recurrences appeared about every two weeks and lasted one or two hours, except when hot drinks terminated them abruptly. The patient thought she could anticipate an episode by a burning sensation in the tip of the tongue on several occasions. Vertigo had become frequent since the first attack, but no visual disturbance or headache were noted.

She was admitted to the hospital for diagnosis. Her head was of normal size and shape; the nose, throat and ear examinations were negative. The thyroid showed no enlargement or adenoma. Heart and lungs were normal. Her abdomen was obese with low midline scar (previous tubal pregnancy). The Liver and spleen were not palpated. No masses, tenderness or muscle spasm could be made out. Vaginal and rectal examinations were negative. A marked lordosis of the lumbar spine was present, as well as marked bowing of the femurs, which caused the patient to cross her legs scissor-fashion while lying in bed. Reflexes were normal except for the pupils which reacted sluggishly to light. Visual fields were normal, eye grounds normal.

X-ray examination of the skull showed normal sella and changes of osteitis deformans. Pelvis and femurs showed osteitis. Laboratory findings were as follows: Blood-hemoglobin 90 per cent, red blood count 4,540,000, color-index .9, leucocytes 9,200. Differential: segmented 51, rod. nuclei 4, lymphocytes 45. Wassermann: plain antigen negative, cholesterinized 2 plus, Kahn 1 plus. Spinal fluid: negative including Wassermann and Kahn. Chemistry: non-protein nitrogen 30, calcium 10.7, phosphorus, 7.8, fasting blood sugar 66; glucose tolerance (after ingesting 100 Gm.) fasting 31 mg. one-half hour 176, 1 hour 152, 2 hours 111, 3 hours 107, 4 hours 50. Blood sugar response to adrenalin (1:1000) 1 cc., fasting 60 mg. 1 hour after 72 mg. Blood sugar response to insulin 10 units; fasting 54, 1 hour 58, 2 hours 54.

Episodes of noisy confusion and disorientation accompanied at times by muscle twitching occurred several times daily. Between 5 and 7 A.M. one would appear daily, and frequently before lunch and dinner as well. They were quickly relieved by sugar or orange juice, and were followed by retrograde amnesia. Withholding food would bring one on in three or four hours. An aura of a burning sensation in the tip of the tongue sometimes preceded the attack by an hour or more. On a high carbohydrate diet with three-hour feedings, the attacks did not recur, so the patient was allowed to return home for a trial period of six weeks.

Diagnosis: Hyperinsulinism and osteitis deformans.

Second Admission. On the fifteenth day after discharge, the patient fell and fractured her left femur. For the first ten days after leaving the hospital no hypoglycemic attacks occurred, but they then began to reappear and became more and more frequent. It was necessary to take some food every three hours during the night as well as day. The examination was unchanged except for a transverse fracture of the left femur.

In the hospital on a high carbohydrate diet with three-hour feedings, no hypoglycemic episodes appeared from date of admission to April 23, 1940 when an open reduction of the femur was done. Her postoperative chart was uneventful except for symptoms of weakness and diaphoresis. However, during the third week and in spite of the frequent feedings of carbohydrate, symptoms of hypoglycemia recurred more frequently. At least three or four appeared each day but were relieved by sugar.

Laboratory findings were repeated and unchanged. Glucose tolerance showed fasting 33, one-half hour 140, 1 hour 129, 2 hours 117, 3 hours 111, 4 hours 50 mg. A diagnosis of hyperinsulinism probably due to islet tumor was made, and it was decided to explore the pancreas.

Through a wide transverse incision about 2½ inches above the umbilicus, the abdomen was opened. The liver, spleen, stomach and intestines appeared normal and the lesser sac was entered through the greater omentum. The stomach was turned up and the pancreas exposed. A tumor the size and color of a small plum was found on the superior surface of the gland at the junction of the body and tail. It was soft, friable and encapsulated, lying in a bed of normal appearing pancreas with several blood vessels running into it. It was enucleated easily and the blood vessels ligated with fine chromic catgut. The remainder of the gland appeared normal. A small tissue drain was placed in the bed, and the omentum closed around it. The abdomen was closed with zero chromic catgut in all layers.

Pathological report was encapsulated tumor 4 by 4½ by 2 cm. The tumor is of soft consistency. The cut surface is homogenous and of grayish pink color. (Fig. 1.)

Histologically a fairly uniform character could be observed. The tumor is composed of round or cubical cells with a faintly acidophilic cytoplasm and a round nucleus showing a fine chromatin structure and a small nucleolus. These cells form small trabeculae or solid nests. (Fig. 2.) Smaller or larger areas of these cell complexes are separated by a fine meshwork of connective tissue stroma dividing them into island-like areas. These areas are very similar to Langerhans' islets, except that they are somewhat larger. The similarity is even more pronounced in some places where the connective tissue stroma is augmented. Here the

appearance is definitely that of accumulated Langerhans' islets. (Fig. 3.) The tumor is characterized throughout by its wealth of
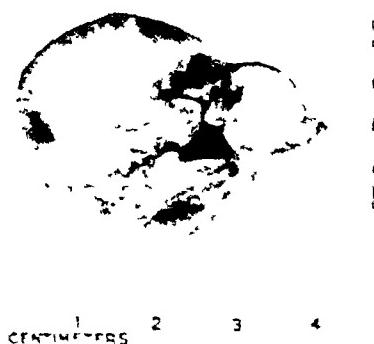
FIG. 1. Gross appearance of the
adenoma.

capillaries, which are not only present in the stroma but appear between the parenchyma cell trabeculae.

Diagnosis: Langerhans' island adenoma of the pancreas.

No further symptoms of hypoglycemia appeared after operation. A glucose tolerance test done a few days after showed a mildly diabetic curve, and on one occasion there was a sugar spill-over in the urine after intravenous glucose was given. The patient ran a low grade temperature and after a few days began to complain of left upper quadrant pain which was aggravated by eating or drinking. There was a moderate amount of serous drainage, and several areas of induration appeared in the subcutaneous fat of the abdominal wall. The leucocyte count increased to 17,000, and the temperature rose gradually. The left upper quadrant pain became referred to the shoulder and back. X-ray of the diaphragm was negative. About three weeks after the operation, it was decided to reopen the left half of the incision because of the localization of pain and tenderness in that area.

At re-operation the sinus from the tissue drain was followed down to a pocket of necrotic fat and pus in the omentum. The pancreas could be felt beneath the omentum, as a hard fixed organ. Bloody serum appeared from the left subdiaphragmatic space and lateral gutter. Tissue drains were inserted in the subdiaphragmatic space and in the abscess of the omentum. The wound was closed with through-and-through silk sutures.

Ten units of protomine zinc insulin daily were given for a few days and the temperature

returned to normal. The pain and tenderness gradually disappeared and the patient made an uneventful recovery.

because they were relieved after ingestion of sugar in some form and they never reappeared after the adenoma was removed.
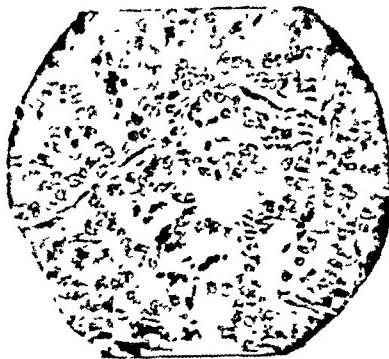
FIG. 2.

FIG. 3.

FIG. 2. Section showing cells arranged in island-like formation. $\times$ 277.
FIG. 3. Section showing area simulating accumulated Langerhans' islets. $\times$ 277.
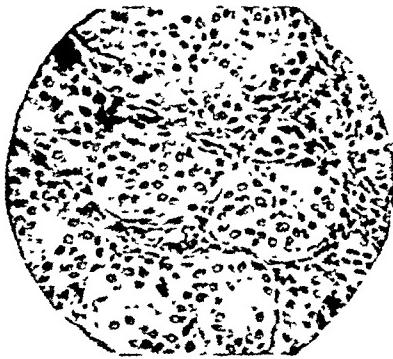
DISCUSSION

The case presented did not cause difficulties in diagnosis after the clinical symptoms were correlated with the laboratory findings. Hypoglycemic conditions caused by disease of other organs than the pancreatic islands (hypothyroidism, hypopituitarism, hypoadrenalism and liver disease) could be eliminated by lack of signs and symptoms pointing to these organs. The differentiation from functional hypoglycemia was done on the basis of: (1) The severity and constancy of the symptoms; (2) the abnormally low fasting blood sugar level and the behavior of the glucose tolerance test, and (3) no permanent results were obtained by dietary measures (high carbohydrate diet, frequent feedings).

There were two interesting features worth mentioning. One was that the hypoglycemia manifested itself mostly in mental confusion, the other was the behavior of the glucose tolerance test.

The symptoms consisted mostly of irrationality, laughing and swearing without reason and retrograde amnesia accompanied by sweating and trembling of the extremities. That these symptoms were really due to hypoglycemia was proved

The glucose tolerance with a subnormal initial value and with a peak not reaching above normal, then dropping down to subnormal again, is too much stressed in textbooks discussing this disease. The tolerance test which presented itself in our case showed a subnormal initial value but the peak reached high above the normal levels, stayed there for one hour and then dropped again to subnormal values. The type which the glucose tolerance will present depends on the individual underlying pathological conditions. The important feature will be the subnormal initial value and the drop to subnormal again within four hours.

SUMMARY

A case report of an adenoma of Langerhans' islet of the pancreas is presented. The symptoms were marked by episodes of mental confusion and irrationality followed by retrograde amnesia.

The glucose tolerance curves were characterized by low initial values with a peak high above normal levels remaining for an hour and dropping again to subnormal values.

The postoperative course was complicated by pancreatitis and a slow recovery.

DIAGNOSTIC POINTS IN INTRA-ABDOMINAL PREGNANCY

REPORT OF A CASE

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INTRA-ABDOMINAL pregnancy, exclusive of tubal pregnancy, though uncommon, is not a rarity. The purpose of this article is to point out the salient points in order to assist others, especially the general practitioner, to keep in mind the possibility of intra-abdominal pregnancy.

Two cases of combined intra-abdominal and intra-uterine pregnancy are referred to in the report by Hellmann and Simon.[3] An occasional case of intra-abdominal pregnancy despite a previous hysterectomy has been reported. Likewise, intra-abdominal pregnancy may follow as the result of rupture of the uterine scar after a previous classical cesarean section. Abdominal pregnancy usually is secondary to tubal pregnancy following either tubal abortion or rupture.

The reported instances of intra-abdominal pregnancy show a marked variation. Swanson states that it occurred in one out of 2,300 births in the series which he reviewed, Kiefer one in 4,400 cases, whereas Harnes, reviewing the files of the New York Lying-In Hospital, found one in 15,600. The mortality has been high in the Lying-In Hospital group, as much as 40 per cent. Beck, after reviewing the literature from 1809 to 1919, arrived at a figure of 35.6 per cent mortality in 257 cases. Hellman and Simon in a study of 316 collected cases, stated that the fetus in 158 patients lived eight days or more. The mother and child lived in only eighty of these cases. Of the total 316 mothers, 101 died, the outcome of three being unknown.

SYMPTOMATOLOGY

Since most intra-abdominal pregnancies are secondary to previous ectopic pregnancy, the early symptoms would be those of tubal pregnancy. They may, however, be so mild that the patient may not consider it necessary to consult her physician, or if the latter be called in, the patient not feeling acutely ill, might not accede to his advice to undergo an immediate laparotomy. From then on, the patient might go on to term without any exceptional symptoms and the unusual type of pregnancy be unsuspected until normal labor fails to set in. More commonly, however, because of the close proximity of the fetus to the abdominal wall and to various abdominal viscerae, movements of the fetus cause intense pain and the abdominal wall is unusually tender. At times so sensitive is the abdominal wall that the pressure of clothing is unbearable. This was borne out in the case being reported, pain on walking being so marked at times, that relief was obtained only by lying motionless in bed. Fetal parts are felt with unusual ease. Nausea and vomiting frequently are present throughout the latter months. Coupled with excessive nausea and vomiting and the extraordinary and troublesome generalized abdominal, gaseous distention, also a common finding, marked localized tenderness and a sense of rigidity in the right upper quadrant may lead one to believe that the gallbladder is pathologically involved. Such was the case in the patient whose history is later reported, the localized tenderness, mass and sense of rigidity in this instance being due to the head of the fetus which was in close contact with the right upper quadrant of the abdominal wall. The excessive pain resulting from fetal movements may be brought about by the stretching of adhesions that have formed between the fetal sac and the abdominal

viscerae. It was surprising that no mention in the literature was made of intestinal obstruction caused by such adhesions.

FIG. 1. Plain plate of the abdomen revealing fetus completely to the right of the spine of the mother

An interesting finding is the passage of blood per rectum. In the case reported herein, the patient had suffered from a fissure-in-ano, which had received treatment sometime previous to her becoming pregnant. There was very little bleeding from this fissure during her pregnancy. There are times, however,. when bleeding per rectum in a case of intra-abdominal pregnancy may be quite marked and no pathological condition in the rectum *per se* be found to explain bleeding. Bleeding may follow erosion of the intestinal wall by chorionic villi or as the result of a perforation of the bowel by loose bony fragments following maceration of the fetus. Although the placenta in the case under discussion was implanted upon the sigmoid colon, no erosion due to the chorionic villi took place.

Constipation and diarrhea may be present but are of no differential assistance in diagnosing an intra-abdominal pregnancy.

When pregnancy persists beyond the expected date of confinement, the possibility of intra-abdominal pregnancy should be

FIG. 2. Lipiodol injection demonstrates a small uterus and clearly demonstrates intra-abdominal position of the fetus

considered if its presence has hitherto been unsuspected. A valuable clinical point in diagnosis was stressed by Nathan Adler[9] who pointed out that percussion of the abdomen in a normal intra-uterine pregnancy usually reveals tympany in the flanks and dullness over the middle area. In intra-abdominal pregnancy the fetus is usually almost wholly to one side of the spinal column and interestingly enough, occupies the right half of the abdominal cavity in most instances. Dullness, therefore, is elicited over that half of the abdomen in which the fetus is situated, with marked tympany being present over the middle and the other half of the abdominal cavity as a result of the intestines being crowded by the fetus toward these areas.

The fetus may live to term, although this is not usual. As in our case, the fetus may expire, no fetal heart be heard, but the mother continue to feel movements. An explanation of this phenomenon perhaps

may be as follows: Due to the adhesions of the fetal sac to the intestines, peristalsis of the latter may give rise to "pulling" pain. The pregnant woman is conditioned psychically to expect pain with fetal movements in the latter months of pregnancy and consequently interprets the "pulling" pain as the result of fetal movements. Despite the physician's inability to hear the fetal heart, the patient will insist that she feels fetal movements.

When confronted with an intra-uterine pregnancy, wherein a fetal heart has been heard consistently and then is no longer heard, the statements of the patient that she feels vigorous movements lends a false sense of security to her physician. He reasons that the baby is still alive and presumes that the fetus probably has assumed a posterior position. When fetal parts, however, are palpable as easily as they are in intra-abdominal pregnancy, failure to hear the fetal heart despite the patient's assurance that she feels movements should lead one to suspect the presence of intra-abdominal pregnancy.

False labor usually occurs whether the fetus dies in the latter months or lives to full term. Even before the onset of such false labor, two valuable procedures, in addition to the physical findings of tympany in percussion over the middle of the abdomen, assist in establishing a diagnosis of intra-abdominal pregnancy. X-ray examination will reveal the presence of a fetus lying almost entirely to one side of the spine, usually to the right. Upon pelvic examination it may be possible to outline the uterus as a mass practically normal or somewhat larger than normal and distinct from the larger abdominal mass which is the fetus. If necessary and without any fear of unpleasant complications, an intra-uterine sound may be introduced. This may be done without a general anesthetic. The introduction of lipiodol through such a sound in the uterus, followed by x-ray exposure will demonstrate conclusively as in the accompanying illustrations, the presence of a nonpregnant uterus with the sound usually pointing in a direction away from the fetus.

AFTER DIAGNOSIS IS ESTABLISHED

Once the diagnosis of intra-abdominal pregnancy has been established, there seems to be no uniformity of opinion on the subject of immediate operation. Some have advised immediate operation; others have suggested waiting until the fetus is viable; still others urge waiting for the death of the fetus so that placental separation may begin.

Although there is a likelihood of minor or major deformity due to mechanical causes resulting from pressure by abdominal viscerae, normal infants have been delivered more frequently than some authors seem to believe.[1] It would seem advisable, therefore, to disregard the suggestion of those who urge operation as soon as the diagnosis of intra-abdominal pregnancy has been established and to wait preferably until the viability of the child has been reasonably assured.

The advice to await the death of the fetus so that separation of the placenta will have begun is unwise and would lead to unnecessary loss of infants. Such delay infers waiting until maceration has taken place. This adds to the danger of sepsis inasmuch as loose fragments of bone may perforate the intestines. Indeed, Halliban, quoted by Swanson,[1] reported a case in which bony parts were expelled per rectum some thirty years after a nondiagnosed intra-abdominal pregnancy. In that case it is quite probable that the fetus failed to attain a size large enough to lead to clinical suspicions of the correct diagnosis.

OPERATIVE TECHNIC

If the fetal sac is not ruptured, it should be opened in an avascular area. The patient should be first typed and cross-matched for immediate blood transfusion should it become advisable. After the fetus has been removed, no effort should be made to separate the fetal sac from any of the loops of intestine or other abdominal viscerae to

which it may be attached, unless this can be done with ease and without damage to the abdominal organs. If the placenta is implanted on pelvic structures, except the pelvic vessels, removal may be possible, especially if a pedicle is present. Interrupted sutures, tied not too tightly, should be utilized in ligating the placental pedicles attached either to the ovary or tube.

It has been suggested by Cornell and Lash[5] that it is safer to marsupialize and pack in such instances of intra-abdominal pregnancy in which the placenta is attached to an abdominal viscus, as for instance, the intestines, the mesentery or liver. This, however, is unnecessary. Beck's experimental work with dogs[5] and the teaching of Falk[6] as well as the author's personal experience in the case herein reported, definitely point to the advisability of tying and cutting the cord close to the placenta, leaving the latter *in situ* and closing the abdomen without drainage. Although quite a long time may elapse before complete absorption of the placenta takes place, this ultimately does occur. In the case herein reported, the fetal sac was adherent in several areas to loops of bowel and contained in its wall good-sized veins. No effort was made to free the sac except where adhesions could be separated without any possible damage to the bowel. A secondary abscess later developed, necessitating an incision and drainage of the wound, resulting most likely from the macerated sac which had been left *in situ*. Abdominal exploration fifteen months later for the relief of pain due to adhesions failed to reveal any suggestion of either fetal sac or placenta. The uterus, left adnexae and sigmoid colon, the site of the placental attachment, were found to be completely normal.

CASE REPORT

Mrs. R. C., age twenty-five, gave a history which was irrelevant and essentially negative, except for regular menstruation lasting eight days with clots about the size of a quarter.

The patient was seen first on September 17,

1936. Menses were due on August 18, 1936 and appeared September 3, 1936. Clots were passed the first two days; staining persisted until the day of examination. Nausea and vomiting were present. Pelvic examination was negative on September 22, 1936; staining was present for a period of nineteen days. Her breasts were slightly tender. An Aschheim-Zondek test was advised because of the inability to feel any possible tubal pregnancy and the presence of prominent Montgomery follicles and slightly tender breasts. The report was positive.

When seen next on October 3, 1936, staining had stopped. A mass, interpreted as a uterus enlarged to the size of a five to six weeks' pregnancy, was palpable. A diagnosis of a normal intra-uterine pregnancy was made and an estimated date of confinement was set at about April 24, 1937. During the next three months, vomiting became troublesome but responded satisfactorily to the administration of luetin injections. What was interpreted as the intra-uterine pregnancy increased in size at apparently a normal rate. Blood pressure and urinalysis remained normal throughout. On December 29, 1936 the patient stated she felt life. On January 18, 1937 the abdominal mass measured 20 cm. and although patient stated she felt life, a fetal heart was not heard. Pelvic examination elicited small parts below, which seemed to move during the examination. The patient stated she was not certain whether she felt fetal movement. X-ray examination was advised.

X-ray examination done January 19, 1937 by Dr. Louis Nathanson was reported as follows: "There is evidence of a single pregnancy entirely within the pelvis. The uterus rises to the level of the upper portion of the sacrum. The head is situated to the right of the midline and overlies the sacroiliac region. Small parts are in the true pelvis. Due to marked overlapping of the parts, one cannot definitely outline spine nor can one differentiate many of the small parts. However, when studied in the lateral view, the outline of the skull is well visualized and much of the facial structures can be demonstrated. The head and facial structures from this view do not appear to be normal. I do not believe from the roentgenogram, that we are justified in concluding that the fetus is abnormal."

Five days later, on January 26, 1937, a fetal heart was heard distinctly in the right lower

quadrant, rate 144. On February 8 and February 9, 1937, the fetal heart was not heard, but movements were felt by the patient. On March 8, 1937, a fetal heart was again heard in right lower quadrant and was heard again on March 22, 1937, April 5, 1937 and April 12, 1937. On April 13, 1937, contraction pains appeared. Rectal examination revealed an apparent one-finger dilatation and diagnosis of breech with buttocks presentation was made. X-ray examination by Dr. Louis Nathanson was reported as follows: "Evidence of a single pregnancy breech presentation with almost the entire fetus on the right side. Head is in the right upper quadrant. The skeletal structures of the fetus are well developed."

The patient was admitted to the Madison Park Hospital, but discharged the following day with diagnosis of false labor. Considerable pain over the next two days was felt in the right upper quadrant of the abdomen with marked tenderness present. In the light of subsequent findings, the normal temperature and the lack of vomiting, what was thought to be a possible cholecystitis was probably the disturbance in the right upper quadrant, brought about by the movement of the fetal parts.

From April 15, 1937 to April 26, 1937, occasional vomiting was present. On April 26, 1937, the fetal heart seemed distant and on May 3, 1937 it was impossible to state definitely that the fetal heart was heard. Movements were no longer definitely discernible to the patient and on May 10, 1937 the movements were practically no longer felt and the fetal heart was not heard. On May 20, 1937, dark, bloody vaginal staining was present. No fetal heart was heard. The patient was not toxic and failed to respond to castor oil in an effort to induce delivery. X-ray examination revealed overlapping of the skull bones, a breech. Pelvic examination gave the impression of the fetus being extra-uterine.

On consultation by Dr. Adler, he corroborated this impression. On May 23, 1937 lipiodol study and sounding of the uterus revealed a uterus about the size of three months with the intra-uterine sound turning to the left side. On May 24, 1937, Dr. Thurston Welton, called in consultation, likewise agreed with the diagnosis of abdominal pregnancy and on that day, through a suprapubic midline incision, an operation to remove the fetus was done. A macerated fetus about seven months in size was found in a sac occupying the right side of the abdomen. The sac was adherent to loops of the bowel. Friable adhesions were easily separated. The placenta was found attached to the sigmoid colon and enveloped the left tube. The left tube was easily freed. The uterus was enlarged to about a three months' pregnancy. The fetus was delivered as a breech. An effort to remove the placenta led to bleeding. It was then determined to leave the placenta *in situ*, recalling that Beck's work with dogs demonstrated conclusively that the body can well take care of the situation and complete absorption of the placental tissues occurs. Iodoform packing was placed against the bleeding placental site. On the fifth day, postoperatively, the packing was removed under 4 cc. of intravenous evipal anesthesia and on June 10, 1937, the patient was discharged from the hospital with the wound healed and in good condition.

Nine days later a temperature of 100.6° (r) appeared. No definite evidence of wound infection nor of abdominal collection was found. On June 29, 1937, a sedimentation test revealed a rate of 100 in one hour, compared to a normal of 20. Pelvic examination revealed a mass in the left lower quadrant which was thought to be the placenta. Sedimentation test repeated on July 13 and July 20 were still 100 in an hour. On August 9, 1937, the temperature was 101.6° (o) with considerable suprapubic pain and the presence of a tender mass was noted. Local applications and Trendelenburg position were prescribed. On August 14, 1937, adequate softening being present, the mass was opened under local novocaine infiltration and a large amount of thin, light, greenish-yellow pus was evacuated. The possibility of this being from an intraperitoneal site instead of being limited to a wound infection was kept in mind. Drainage continued with the temperature ranging between 99 to 100° (o) until September 11, 1937, when the patient felt quite well. On September 13, 1937 a small pocket at the upper end of the wound was opened under local novocaine and a slight amount of discharge evacuated. On September 17, 1937 menses appeared, small clots being present. On October 23, 1937 lipiodol injection into the fistulous tract and x-ray examination were done in an effort to determine whether the discharge that still persisted, though slight,

was coming from the side of the placental attachment, or from a broken down sac which had been left in the abdomen. A blood chemistry on October 23, 1937 was reported as follows: glucose 96 mg./100 cc. blood; urea N. 17.6 mg./100 cc. blood; cholesterol 160 mg./100 cc. blood. Sedimentation curve showed a slight to moderately active reaction. Culture of pus from the sinus revealed a Staphylococcic albus. A blood Wassermann test was negative. Menses reappeared six weeks later. Foreign protein injections were administered. The drainage from the sinus gradually diminished, probably an after-effect of the injection of lipiodol. On November 14, 1937, it was impossible to visualize any lipiodol in the abdomen. Temperature became normal on December 2, 1937. Drainage was scanty and by January 15, 1938 the wound was perfectly healed. Sedimentation rate was normal and on pelvic examination the uterus was felt to be in good position, slightly subinvoluted and the adnexal regions were normal except for slight tenderness at the left fornix, no mass being palpable. Special care was taken to note whether it was possible to feel the retained placenta.

During the months from February to July 1938, the patient felt well, except for a persistent "pulling pain" in the region of the wound, especially noted when standing up from a sitting position. It was suggested to her that the cause of this pain might be due to postoperative adhesions to the wound and that liberation of these adhesions might bring about relief. On August 2, 1938, the patient was readmitted to the Madison Park Hospital and under open ether anesthesia the lower half of the scar was excised. There was evidence of old necrotic tissue in an area about 1 cm. in diameter through which the former sinus opened. This, however, was not connected with the abdominal cavity. There were adhesions of the omentum to the scar and a loop of the small intestine was attached to the abdominal aspect of the wound. The uterus was in good position and appeared normal. The right tube and ovary and left tube were normal. The left ovary was cystic and slightly enlarged. The descending colon and sigmoid were perfectly normal. No evidence of any fistulous tract was present nor were there any signs whatsoever of amniotic sac nor of the placenta which had been left *in situ*. The adhesions were separated after double ligation and the loop of the small bowel was freed. The abdomen was closed without drainage. Twelve days later the patient was discharged in good condition.

Progress of the case has been normal and when last examined on June 29, 1940, no evidence of pelvic abnormality was elicited. A tubal insufflation test, done because of the patient's inability to become pregnant, revealed patent tubes.

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MOBILE CECUM WITH LEFT HYDROCELE*

CASE REPORT

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BALTIMORE, MARYLAND

ACCORDING to W. R. Houston, about 20 per cent of persons have a mobile cecum as the result of a fault in embryonic development. This is usually due to an absence of fixation of the ascending colon to the posterior abdominal

position that it can be considered of significance.

CASE REPORT

W. M., No. 62495, age fifty-five, was admitted to the University Hospital with the
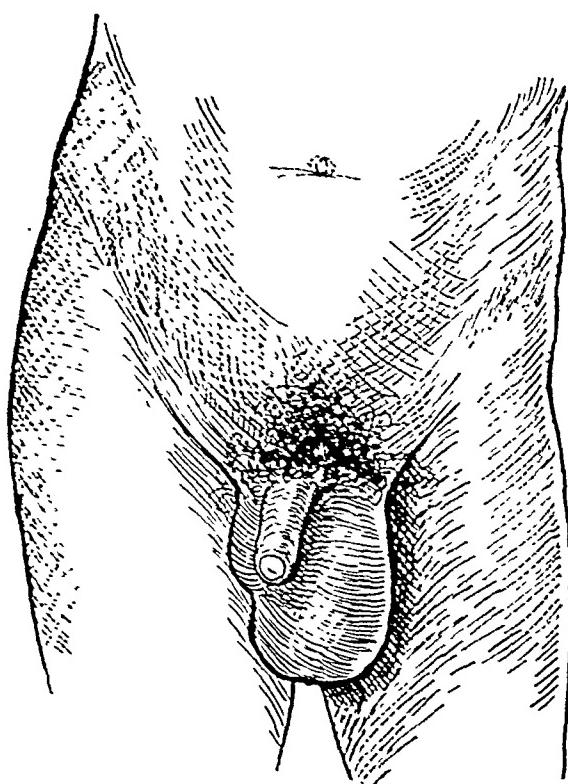
FIG. 1. Showing scrotal mass.

wall. Failure of rotation of the cecum may result in a wide range of variation in its position. From the autopsies performed on infants at the New York Foundling Hospital, the cecum was found on the left side of the abdomen in five cases, two in the male and three in the female. From an x-ray viewpoint the cecum is often seen to be mobile, so that it is only when fixation of the cecum takes place in an abnormal
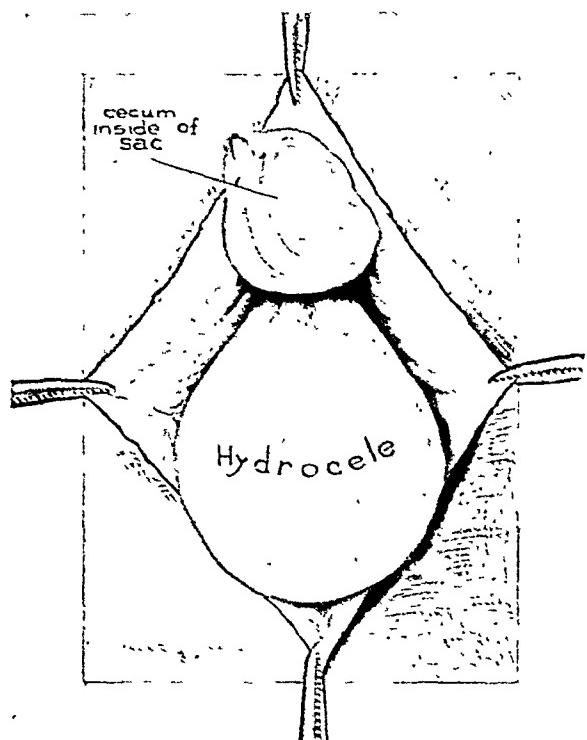
FIG. 2. Showing the relation of the hernial sac to the hydrocele.

complaint of swelling in the left side of the abdomen with a history of a gradual increasing enlargement of the left scrotum over a period of four to five years, the condition being practically painless. The history as to trauma or infection of the urinary tract was negative. The physical examination was essentially negative except for a large mass in the left scrotum. This mass was about the size of the doubled fist; the skin was tense but there was no external indication of inflammation. The lowermost portion trans-illuminated light but the upper portion

* From the Urological Department, University of Maryland.

was opaque. A diagnosis of left hydrocele and left scrotal hernia was made. A barium enema

straw-colored hydrocele fluid was excised. The patient recovered without complications.
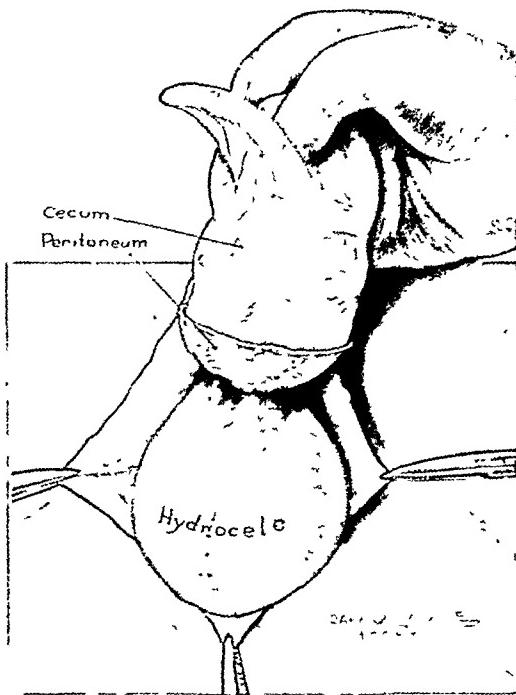
FIG. 3. Showing the cecum and appendix in the hernial sac.

showed the cecum in the right lower quadrant but somewhat irregular. At operation a large hernial sac was first uncovered. Upon opening the sac the appendix immediately appeared. The entire cecum was loose and easily replaced in the abdomen. An appendectomy was performed and the hernial sac closed off, after which a herniotomy was done. The hydrocele sac which contained about 250 cc. of clear,

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New Instruments

DOG SURGERY

DESCRIPTIONS OF TECHNIC FOR ANESTHESIA AND OF A RESPIRATOR FOR THORACIC SURGERY PRACTICE

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EMPORIA, KANSAS

IN a recent editorial in the *American Journal of Surgery* it was suggested that the small town surgeon can practice surgical technic by operations performed on dogs. Comment was made upon some of the surgical procedures which lend themselves to this form of self-development.

Facility acquired in the handling of instruments, suture materials and tissues has been a valuable reward for the time given to this work. Operations done infrequently in general surgical practice become routine procedures to one who employs this means for developing technic. New operations are given trial and pitfalls may often be recognized before the human patient is exposed to them. Thus, dog surgery is a method for improving skill which can be of service to both the beginner and the accomplished surgeon. It can be made available anywhere at a cost which is negligible.

We wish to outline our routine preparation of the animal for surgery and to describe a homemade apparatus which makes possible open thoracic surgery without the aid of an assistant.

We have an arrangement with a man whose home is sufficiently isolated to prevent public observation and comment. He obtains the dog from the pound in another city and when, at the appointed time, we arrive at his home the dog is anesthetized, shaved, and in position on a homemade operating table in his basement. The instruments and gloves are ready and work begins at once.

The procedure for preparing the dog is as follows: A canvas bag with a draw string is placed over the animal's head to prevent biting. The forelegs are tied together and this rope passed around a post. The hind legs are then tied together and the rope tied around another post and drawn snug so that the dog lies on the floor, stretched between the two posts.

The anesthetic solution consists of 15 Gm. of chloretone dissolved in 100 cc. of rubbing alcohol. The initial dose is 1/2 cc. per pound body weight and this amount is drawn into a 10 cc. unbreakable veterinary syringe with a large gauge needle and is injected in a single dose into the peritoneal cavity. Deep surgical anesthesia is present in from seven to ten minutes and the dog is then ready for the operating table. Occasionally, a second injection consisting of 1/4 to 1/2 of the initial dose is necessary. This may have to be repeated once or twice during the morning. Anesthesia has thus been maintained in our experience for from six to seven hours, at the end of which time the condition of the animal was still quite satisfactory. We have lost only one dog by anesthesia death and this was due to an error in calculation which resulted in an initial overdose.

This form of anesthesia is convenient, inexpensive and highly satisfactory, requiring no anesthetist during the operations. In the event that narcosis becomes too deep while the work is in progress the peritoneal cavity is washed out with normal saline and

a few minutes of artificial respiration have sufficed, in our experience, to revive the animal.
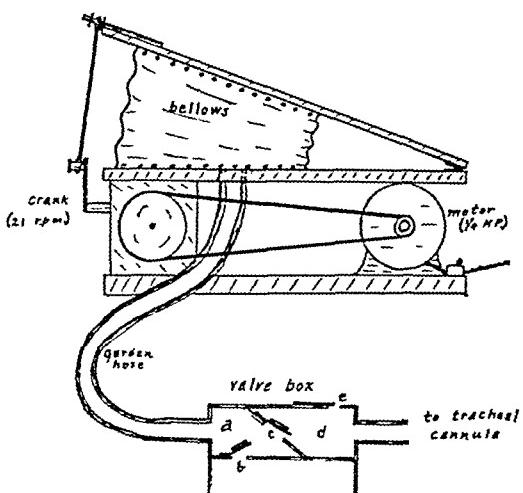
FIG. 1. Diagram of respirator for surgical procedures in the dog's thoracic cavity.

The operating table is home made with a top that measures forty-six inches long by twenty-two inches wide. This leaves a space at one end for instruments. The dog lies upon his back and a rope around each

FIG. 2. Photograph of homemade respirator employed by the authors.

leg is tied to the table beneath. The abdomen is shaved and draped with towels. This completes the work of our assistant until the time comes for disposal of the remains.

At the close of the operation the dog is killed by any of several means, the simplest being to leave the pleural cavity open for a few minutes.

Training in the more recently developed field of thoracic surgery is apt to be lacking in the experience of many competent general surgeons. Dog surgery affords valuable practice here. However, unlike the human structures, the dog's mediastinum and pericardium are thin friable membranes, and it is impossible to expose the heart or one lung without collapsing both lungs. Thus a respirator becomes necessary.

Most respirators for animal work operate on compressed air or vacuum lines which are available in many large laboratories. Such is the principle of an ingenious device made from a windshield wiper designed and demonstrated to us recently in Dr. Claude S. Beck's laboratory at Western Reserve University.

The apparatus we employ (Fig. 1) requires no pressure or vacuum line. It is simple to construct, inexpensive and operates on any light circuit. The gears and crank are from an old washing machine, and together with the motor may be obtained for about five dollars from any dealer in washing machines. The pulleys selected are of such ratio that the crank makes twenty-one revolutions per minute and operates a bellows which handles about two liters of air. A garden hose connects the bellows to the valve box and this in turn connects to a tracheal cannula inserted by tracheotomy.

Fresh air is insured and overdistention avoided by means of the valves and vent as illustrated. Our earlier work was done without valves, but the addition of this unit gives much better results. We have found

that overdistention of the lungs proves fatal to the dog—a warning to those who use positive pressure methods on human patients.

The mode of operation of the respirator is as follows:

Tracheotomy is done and the inserted cannula connected with a short hose to chamber *d*. Vent *e* is open and the dog breathes through here. The motor is started and, as the bellows close, air enters chamber *a* and passes through valve *c* into chamber *d* where it, too, escapes via the vent *e*. As the bellows open, valve *c* closes and fresh air enters at valve *b*.

The thorax is now opened and the lungs observed as they collapse. Partial closure of vent *e* is now commenced and checked at the point where the lungs fill gently without rounding the margins, which should remain as rather sharp edges. The elasticity of the lungs will collapse them, causing exhalation through the remaining aperture at vent *e*. No negative pressure from the machine is needed. If for any reason ether anesthesia is preferred, an "ether bottle" may be cut into the circuit between the valve box and the cannula. The valves consist simply of holes with leather flaps on which small coins are glued.

The apparatus is rugged and dependable and can be used by a surgeon working without assistance.

It is our sincere hope that the foregoing account may induce others to avail themselves of this opportunity for practice in surgical technics.

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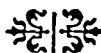
THE PHILLIP'S RECESSED HEAD SCREW

ARCH F. O'DONOGHUE, M.D.

SIOUX CITY, IOWA

THE widespread revival of the use of internal metallic fixation in the treatment of fractures which has followed

FIG. 1. 1, Self-retaining screw driver with the Phillip's head; 2, ordinary driver with Phillip's head; 3, Phillip's recessed head screw made of vitallium. Note it is impossible for driver to slip off this screw head.

the work of Venable and Stuck on the minimal tissue reaction when using vitallium has brought the mechanical difficulty of internal fixation again to mind. The long period elapsing between Venable's work and the disuse of internal fixation because of the numerous nonunions and low grade infections resulting from the original Lane plate did not of course stimulate a search for better mechanical methods to introduce such fixation onto bone. Many who have been using internal screw fixation probably have had the same trouble that we have had in driving the screw into bone in wounds which are always somewhat bloody, because the screw head becomes slippery and the ordinary screw driver will often, during the application of a single plate, slip off the screw and jab into the patient's unprotected soft parts, much to the annoyance of the surgeon and actual damage to the patient.

Three years ago a screw called the Phillip's recessed head screw was brought out in industry primarily for use in putting together highly finished automobile parts because the automobile mechanics were having this same trouble of slipping. The head of this screw has not a single slot but a double one, the slots being at right angles to one another so that a driver head made accurately to fit this screw head cannot slip off. With the idea of applying this same principle to the use of vitallium we have some months ago had a driver and screws cast on this principle and have been highly gratified by their use. The time of driving the screw is much less; the driver never slips off the screw and jabs the patient, and the actual asepsis is better because the surgeon is not tempted to use his free hand to steady the end of the driver in the slot in the screw. The illustration shows plainly how this principle is applied.

THE ELIMINATION OF AIR BUBBLES FROM INTRAVENOUS APPARATUS BY A MODIFICATION OF THE MURPHY DRIP

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Surgeon-in-Chief, Windham Community Memorial Hospital

WILLIMANTIC, CONNECTICUT

THE apparatus used for giving fluids intravenously is essentially the same in all hospitals. An inverted flask

Fig. 1.   Fig. 2.   Fig. 3.

Fig. 1. Usual type of dripper.   Fig. 2. Modification a.   Fig. 3. Modification b.

containing the desired solution is connected by rubber tubing, or directly, to a glass bulb of the Murphy drip type. This, in turn, is connected by tubing of various lengths to the needle which is inserted into the vein. The rate of flow is regulated by a small clamp on the rubber tubing either above or below the Murphy drip glass bulb.

Before the needle is inserted into the vein an attempt is made to eliminate all air from the tubing below the bulb. This can be done in several ways and each individual soon develops a technic of his own. Each method, however, is more or less time consuming, and various amounts of solution are wasted. At times it is difficult and annoying to eliminate small bubbles from the tube.

The Murphy drip (Fig. 1) was originally intended and used for the rectal administration of fluids so that the elimination of air bubbles constituted no problem. When used, however, for intravenous therapy the Murphy drip has a definite defect. The small glass tip or dropper projects into the bulb in a straight line, so that when fluid is allowed to run from this tip through the bulb, the solution carries with it air from the glass chamber into the tubing.

If, however, the glass dropper is curved (Fig. 2) and the solution directed to the side of the glass bulb, practically no air is carried into the tube. The same result can be achieved by using a straight glass tip and directing the solution to the side of the bulb by indenting a small area of the bulb itself. (Fig. 3.)

In using these bulbs the flask containing the solutions is inverted with the clamp on the tubing closed tightly. The clamp is then opened widely, allowing a full stream of fluid to run down the side of the glass bulb. Within a few seconds the tubing is free of all air bubbles and only a tablespoonful of the solution is wasted. Both types of bulbs have been used at the Windham Community Hospital with great satisfaction.

MODIFIED BRAUN PERINEAL SCISSORS

HAROLD D. CAYLOR, M.D.

Caylor-Nickel Clinic

BLUFFTON, INDIANA

FOR surgeons who, after incising the peritoneum with a knife, prefer to lengthen the incision with scissors we

In opening the peritoneal cavity after the peritoneum is nicked with a knife this modified Braun shears (Fig. 1, no. 2) can
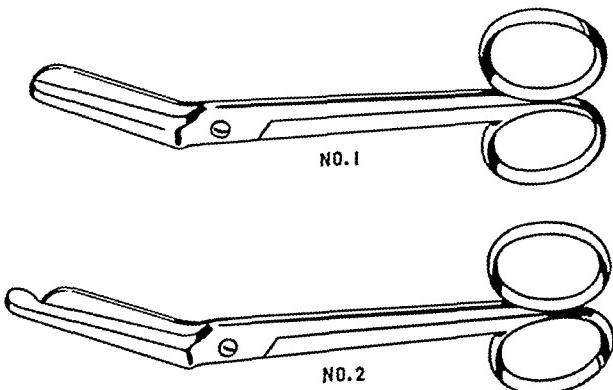
FIG. 1. Modified Braun perineal scissors.

have modified the Braun perineal scissors so that they are more adaptable for this purpose.

In the original Braun scissors one blade of the cutting edge was set at right angles to the other. (Fig. 1, no. 1.) By adding a nib to the lower flat blade of the shears we have, we believe, improved the instrument.

be inserted; and because of the nib and flat blade the omentum, loops of bowel and other structures that commonly tend to impede this step are easily pushed aside. The incision can then be rapidly and safely completed.

We have used this instrument for many months with great satisfaction.

Selected Book Review

OPERATIVE SURGERY*

Edited by Frederic W. Bancroft, a.b., m.d., f.a.c.s.

WE quote in part from the Preface: "The purpose of this volume is to present surgical treatment of abdominal diseases together with such important subjects in the general field as anesthesia, pre- and postoperative treatment, the fundamental principles of surgical technic and blood transfusion. . . . We are fortunate in having the collaboration of authors whose high attainments in their chosen specialty enable them to best present their respective subjects and the technic of operations that have proved to be of the most value. . . . They represent the best surgical thought of today . . . one can choose only one author for a given subject, while there are many other excellent authorities whose absence we regret. . . . The subject matter is entirely of surgical treatment and is not concerned with etiology, pathology or diagnosis with the exception of the surgery of the spleen. Emphasis is placed on presenting the best methods by masters of each subject and not encouraging unnecessary surgery." Thus we have the blueprint.

R. Charles Adams did the chapter on Intravenous Anesthesia; Arthur W. Allen wrote on Surgery of the Small Intestine; Anthony Bassler on Dieting for Abdominal Conditions in Which Operations Have Been Performed; Woolfolk Barrow on Appendicitis; Alfred Blalock on Preoperative and Postoperative Treatment; Donald E. Brace on Preanesthetic Medication; Frederick A. Coller on The Treatment of Peritonitis and Peritoneal Abscesses; John H. Garlock on Surgery of the Esophagus; A. Stephens Graham on The Colon and Rectum; Roscoe R. Graham on Surgical Therapy in Lesions of the Stomach and Duodenum; Fraser B. Gurd on Abdominal Incisions; Robert Hayward Kennedy on Surgery of the Mouth; Edward M. Kent on Jejunal Ulcer; Urban Maes on Surgery of the Spleen; Samuel McLanahan on The Anus; Alton Ochsner on Appendicitis;

William Barclay Parsons on Diseases of the Pancreas; Damon B. Pfeiffer on Jejunal Ulcer; Fred W. Rankin on The Colon and Rectum; I. S. Ravdin on The Surgery of Diseases of the Liver;
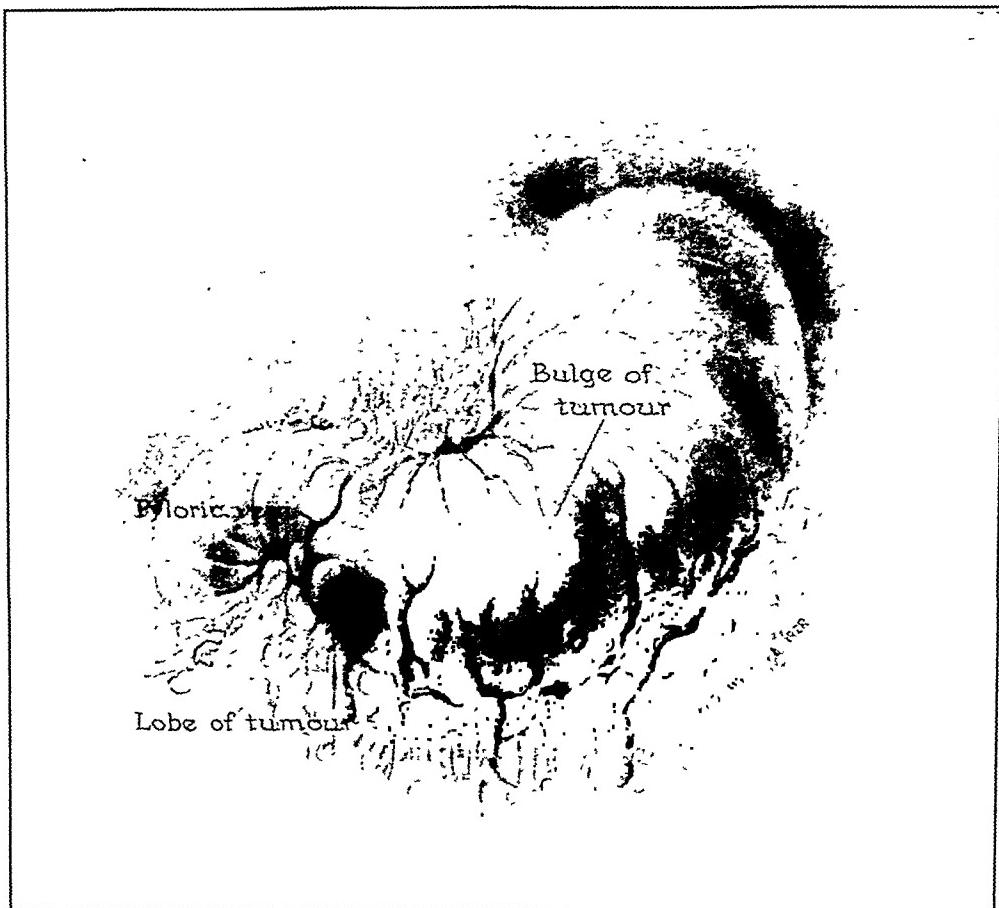
FIG. 1. Intramural neurofibroma of the pylorus. Illustrates the large proportions which benign tumor of the stomach may reach before producing symptoms. In this instance the multilobular tumor was a neurofibroma producing massive hemorrhage. (Fig. 36, on page 628, in Bancroft's "Operative Surgery." D. Appleton-Century Company, Inc.)

Mont R. Reid on The Fundamental Principles of Surgical Technic; James D. Rives on Surgery of the Spleen; D. E. Robertson on Congenital Pyloric Stenosis and Trauma of the Duodenum; Henry S. Ruth on Regional Anesthesia; Rudolph Schindler on The Significance of Gastroscopy for the Surgeon; H. J. Shields on Spinal Anesthesia; Rufus E. Stetson on Blood Transfusion; Jean M. Stevenson on The Fundamental Principles of Surgical Technic; Harvey B. Stone on The Anus; Claude E. Welch on Surgery of the Small Intestine; Allen O. Whipple on Surgery of the Biliary Tract; Sidney Cushing

Wiggin on Inhalation Anesthesia; and Paul M. Wood on Rectal Anesthesia.

We are sure that in listing the authors and their subjects the
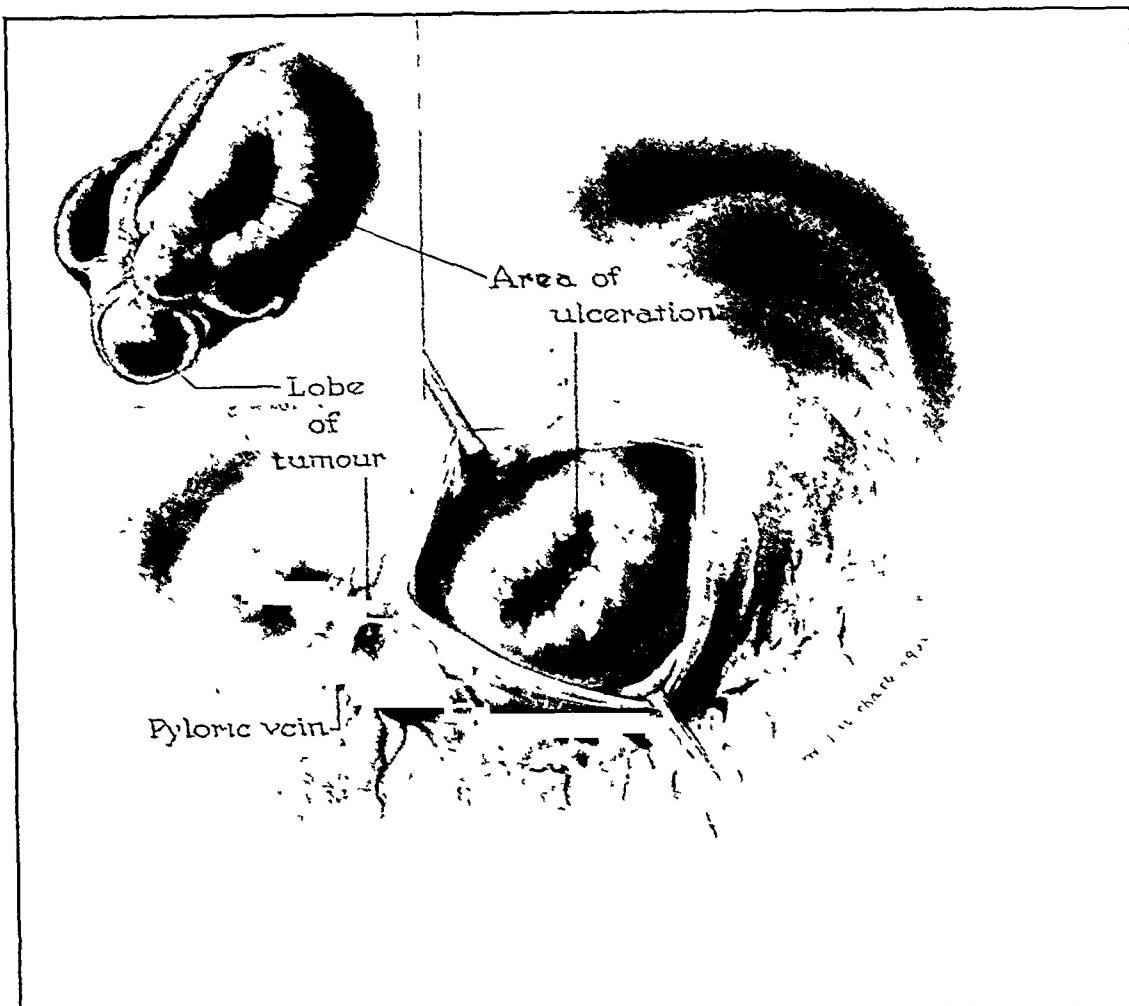
Fig. 2. Continuation of Figure 1. Presenting the intragastric appearance of the tumor and also the tumor enucleated. The area of ulceration represents the source of hemorrhage. This patient, operated upon twelve years ago, is perfectly well. (Fig. 37, on page 629, in Bancroft's "Operative Surgery." D. Appleton-Century Company, Inc.)

reader will get a correct prospective of the work as a whole. To deal with each author and his subject would cause this review to reach the length of a small monograph. Suffice it to say that each and every author has done a thorough and workman-like job of the task given him. The book as a whole is good reading; that it is authoritative cannot be questioned.

The book, containing 1,102 pages, has hundreds of illustrations some of which are in color, and these illustrations are far above the usual level in perfection of detail. There are references at the end of each chapter and there is an ample Index.

Up to this point we have been factual. However, we believe that the reader, if interested in operative surgery, will be impressed that this is an unusual work, of a high order of merit, and the last word to
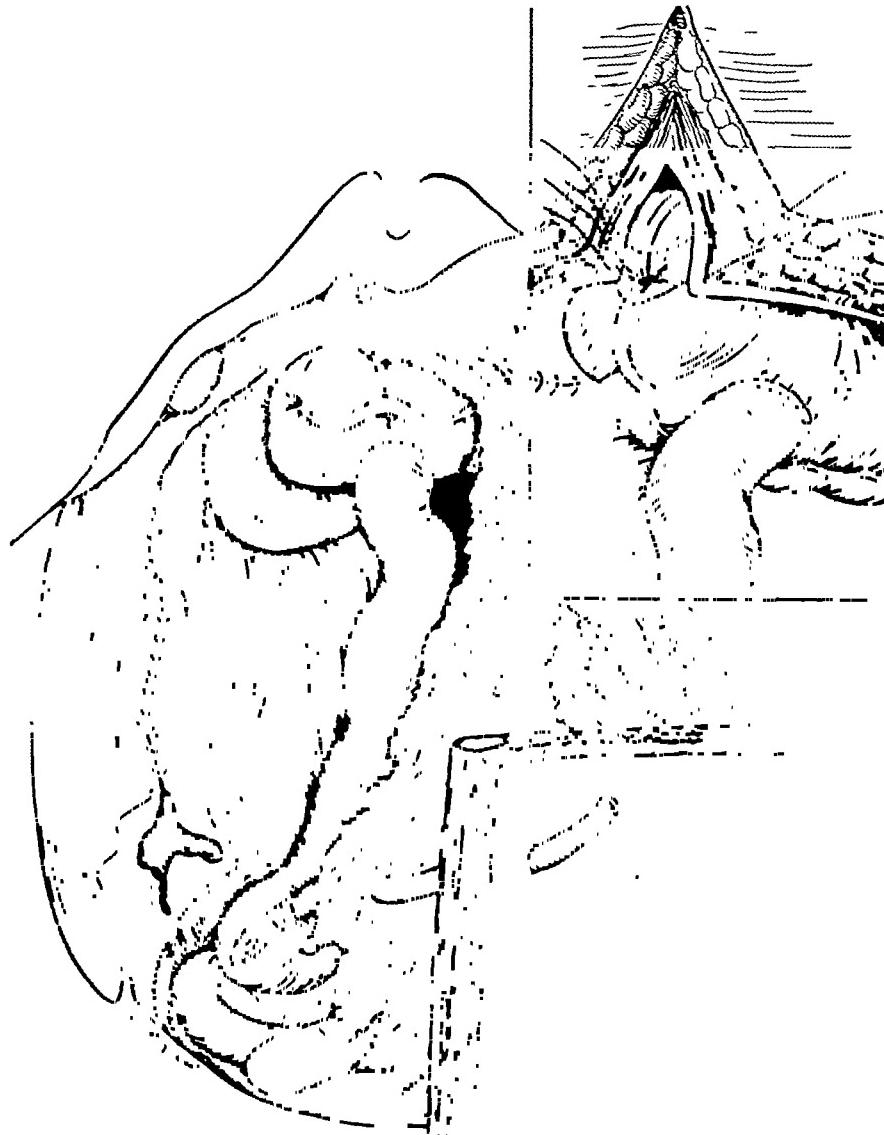
Fig. 3. Resection of the right half of the colon completed and the raw surfaces left by the dissection have been closed by a continuous suture. Insert shows inversion of divided end of transverse colon. (Fig. 11, on page 837, in Bancroft's "Operative Surgery." D. Appleton-Century Company, Inc.)

date on the topics included between its covers. From every viewpoint, it is one of the outstanding surgical volumes published this year.

CANCER

of the

GUMS (GINGIVAE)

BY

HAYES MARTIN, M.D.

Attending Surgeon, Memorial Hospital

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CANCER OF THE GUMS (GINGIVAE) *

HAYES MARTIN, M.D.

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CANCER of the gums as a distinct anatomic form of intra-oral cancer has received less attention in the medical literature than its relative frequency merits. Its importance has been overshadowed by the greater emphasis placed upon such better known entities as cancer of the lip and of the tongue, and its identity has been further obscured by a lack of clear definition and its inclusion with a group of tumors of adjacent bony and soft parts under the vague term, "cancer of the jaw."

The present report is based upon an unselected and consecutive group of 113 cases of cancer of the gums, including all-comers in all stages of the disease who applied to the Memorial Hospital between the years 1929 and 1935, inclusive.

Definition.† The term, "cancer of the gums" (gingivae) should be used to designate all malignant tumors arising in the soft tissues

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† In the medical literature, gingival cancer is described under a variety of titles, such as cancer of the *jaw*, the *alveolus*, the *alveolar border*, the *alveolar ridge*, the *alveolar process*, the *maxilla* or the *mandible*. Cancer of the upper gum is often discussed with cancer of the antrum and or palate, with no distinction between those growths which arise in the epithelium of the gums and perforate into the antrum, and those which arise in the antrum, erode the alveolar process and perforate onto the gum surface. Reports on cancer of the lower gum often include tumors of bone and of the dental organ. As in all varieties of intra-oral cancer, the greatest confusion results when more than one anatomic group is reported (under such titles as cancer of the "lip and jaw," "tongue and jaw," etc.) without separation of the data.

Much of the confusion in terminology results from the use of the vague term, "jaw," when referring to the gums, or from misdirected attempts to clarify the problem by the substitution of "alveolus," "alveolar border," "alveolar process," etc., rather than the correct term, "gum," which is apparently considered inelegant and unscientific. According to Webster, the term jaw or jaws includes the bone—maxilla and/or mandible— the teeth and the soft structures covering them. This term is, therefore, too inclusive. In anatomical texts there is only one term which defines the soft tissues covering the alveolar processes of the maxillae and mandibles, namely, the *gums*. The term, *alveolus*, refers only to a tooth socket, the terms, *alveolar process* and *alveolar border*, refer only to parts of the bone of the maxillae and mandible.

The confusion in terminology is obvious even in foreign literature. Certain French authors speak of cancer of the "machoire" (jaw) and "mandibule" instead of "gencive" (gum). German authors commonly designate cancer of the gum as "Kiefercarzinom"

overlying the alveolar processes of the upper and lower jaws. Tumors of the gums should be distinguished from those which arise in the bone structure of the maxillae and mandibles and in tooth structures.

The term "epulis" originally referred to all swellings and tumors in this area, particularly to "gumboils" but also to tumors of the bony alveolar processes which surround the alveoli (tooth sockets). At the present time the word bears a more restricted meaning, and in general is used to designate benign tumors of the gums (giant cell epulis, granulation tissue epulis, fibrous epulis, etc.) Etymologically there is no objection to the term, "epulis cancer."

ANATOMY OF THE GUMS

The gums are composed of a thin layer of soft tissue (1 to 2 mm. in thickness) covering the alveolar processes of the maxillae and mandible. The borders of the gums are not sharply defined, but approximately they are delimited (a) on their outer surfaces by the reflection of the mucous membrane onto the cheeks and lips in the depths of the gingivo-buccal gutters and (b) on their inner surfaces by the reflection of the mucous membrane onto the hard palate and onto the floor of the mouth from the upper and lower gums, respectively.

In structure the gums consist of dense, fibrous tissue united internally with the periosteum and covered externally by mucous membrane. They are richly supplied with blood vessels but sparsely with nerves and are covered by stratified squamous epithelium containing numerous papillae, especially in the margins where the gums join the teeth. Around the neck of each tooth the gum forms a free, overlapping collar which is continuous with the alveolar periosteum (peridental membrane) or root membrane of the teeth.

ANATOMY OF THE LYMPHATICS OF THE GUMS

The lymphatic drainage differs in the upper and lower gums and also on their outer and inner surfaces. (Fig. 1.) Anatomists[26,27,29] differ somewhat in regard to the more intimate details of this net-

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(jaw carcinoma), although in German dictionaries there is a word "Zahnfleisch" to designate the gums. Kaufmann (Spezielle Pathologische Anatomie. Vol. 1, p. 533. Berlin, 1931. Walter de Gruyter & Co.) speaks of "Krebs des Zahnfleisches" and also refers to "epulis carcinomatosa." In recent Italian literature there is reference to "epiteliomi gengivali," which appears to have the same significance as "gingival cancer."

work, but from the practical standpoint these details are of only minor importance.

1. *The Upper Gum.* (a) *External or vestibular surface:* (Fig. 1A). The lymphatics of the external surface of the upper gum are continuous with those of the mucosa of the cheek and anastomose across the midline anteriorly. On either side the finer network and collecting tubules unite to form a plexus which runs backward and laterally along the gingivo-buccal gutter to enter the cheek. The vessels of this plexus then pierce the buccinator muscle along its superior attachment and reach the anterior facial vein, which they accompany to the submaxillary region, where they enter into the various nodes of the submaxillary group. The lymph vessels from the anterior portion of the upper gum occasionally run to the preglandular lymph-node, but the main lymphatic drainage from the entire structure goes to the prevascular and retrovascular nodes. In the present series, metastases from the upper gum appeared first in the prevascular submaxillary node in 39 per cent of the cases with metastasis. (b) *Internal or lingual surface:* (Fig. 1B). The lymphatics of the inner surface of the upper gum are continuous with those of the hard and soft palates. The main drainage passes backward beneath the mucosa of the retromolar triangle and posterior part of the cheek to the anterior border of the ascending ramus of the mandible. The lymphatic trunks then incline backward and downward, passing to the inner side of the submaxillary salivary gland, and terminate in the subdigastric nodes of the internal jugular chain.

According to Rouviere,[26] there are two other inconstant routes: first, the anterior pathway by which a few lymphatic vessels from the upper gum, after leaving the retromolar triangle, pierce the buccinator muscle and go to the pre- and retrovascular nodes and, second, the posterior pathway where a few lymphatics from the upper gum pass posteriorly to the retropharyngeal nodes. In our clinic we have never been able to demonstrate clinically the presence of metastases in the retropharyngeal lymph-nodes from any part of the oral cavity or pharynx, although one must concede that enlargement of the retropharyngeal nodes would in most cases be difficult to distinguish from a generalized swelling or edema of the posterior pharyngeal wall so commonly found associated with cancer in this region.

2. *The Lower Gum.* (a) *External or vestibular surface:* (Fig. 1C). The lower external gingival lymphatic network, like that of the

[3]

upper, forms a plexus in the lower gingivo-buccal gutter which anastomoses across the midline anteriorly. In the gingivo-buccal gutter on each side the vessels pass laterally into the cheek, join the
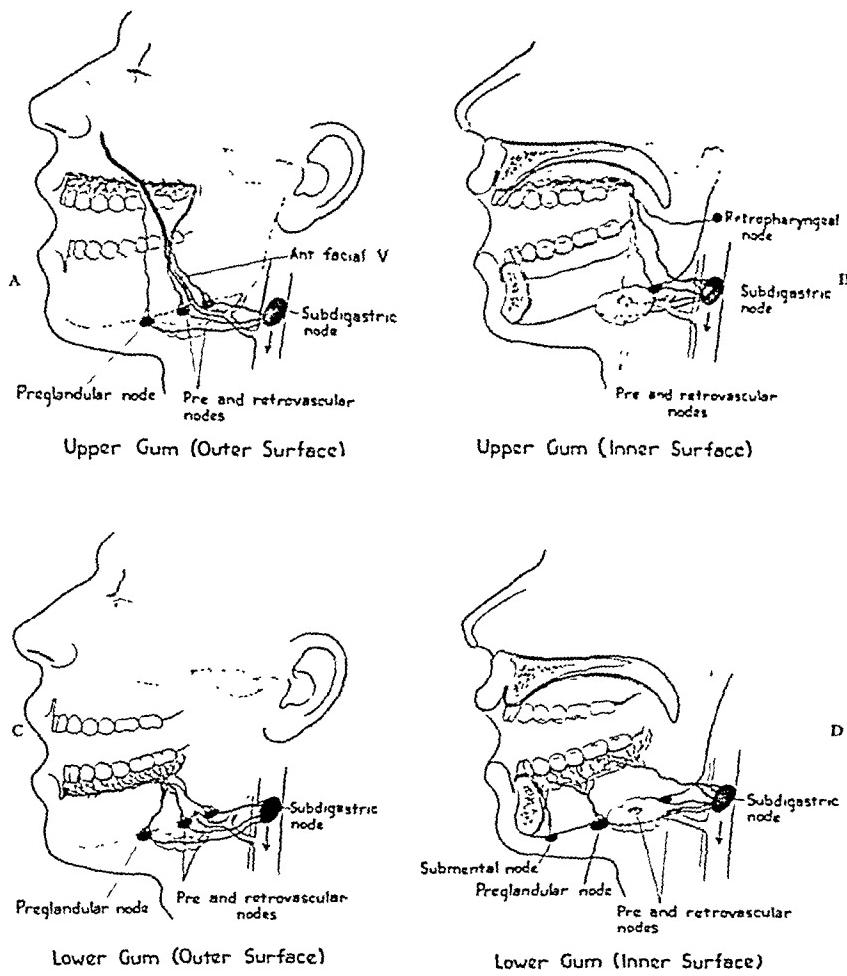
FIG. 1. A, B, C and D, *lymphatic system of the gums.* The lymphatics of the gums drain to the submaxillary and upper deep cervical nodes. The pre- and retrovascular nodes and the subdigastric nodes receive drainage from all of the gum surfaces. The preglandular submaxillary node receives drainage from all except the inner surface of the upper gum. The submental node receives drainage only from the anterior inner surface of the lower gum. The retropharyngeal node receives drainage only from the upper gum.

lymphatics of the cheek, and pierce the buccinator muscle to drain into the prevascular node and, in most cases, into the preglandular and retrovascular nodes as well. (b) *Internal or lingual surface:* (Fig. 1D). The internal vessels make up part of the lymphatic network of the floor of the mouth and undersurface of the tongue; the

larger vessels pierce the myelohyoid and drain mainly into the preglandular node of the submaxillary group. Considerable drainage from this area, especially from the posterior portion, passes directly to the subdigastric nodes of the internal jugular chain. A small part of the lymph from the anterior inner surface of the lower gums passes into the submental nodes with the drainage from the adjoining floor of the mouth.

<div align="center">ETIOLOGY</div>

General Incidence. According to the admission records of the Memorial Hospital, cancer of the gums makes up about 10 per cent of all malignant tumors of the mouth, 7 per cent of all those of the upper respiratory and alimentary tract, and 2.5 per cent of all human cancer. Its incidence is about the same as cancer of the cheek. Kirkham, of Texas,[14] states that gingival cancer is more common in the negro than in the white race, although he gives no figures to prove his claim. In animals, gingival cancer makes up almost 30 per cent of all malignant tumors of the oral cavity,[17] about three times the proportion in human beings.

Age and Sex. The average age of the 113 patients in the present series was sixty-one years, which is slightly older than that of other forms of intra-oral cancer (lip fifty-six, tongue fifty-eight, cheek sixty). The youngest patient was twenty-two and the oldest sixty-six. The disease is definitely more common in the older age groups; almost 70 per cent of the tumors occurred after the age of sixty and only about 2 per cent under the age of forty. About 82 per cent of the patients were males, and 18 per cent females, a relative incidence identical with that reported by Edling[5] in forty cases.

Position of the Growth. In the present series the lower gum was affected in 54 per cent of the cases, the upper in 46 per cent. Gaini[8] has recently reported a series of fifty-three cases in which 68 per cent of the tumors occurred on the lower jaw. The region of the third molar was the most common site of origin (about 60 per cent) in the present series with the region of the bicuspids and canine teeth next in order. Relatively few lesions (5 per cent) arose near the midline anteriorly. Forty-two per cent of the growths were located on the right side and 58 per cent on the left. Janeway, in 1918,[12] reported seventeen cases of cancer of the "superior maxilla" from the Memorial Hospital, of which twice as many occurred on the right as on the left.

Since most growths are fairly well advanced on admission, it is
sometimes difficult to determine the exact point of origin; but from
the position of the smaller lesions and from the direction of the
greatest extension in the larger ones, it appears that the apex of
the gum is most often the primary site, and that if the lesion arises
definitely on one or the other side, the outer surface is the point of
origin about twice as frequently as the inner. In 90 per cent of all
cases extension had taken place to neighboring structures on admis-
sion, which is to be expected since the gums are relatively narrow
(2 to 2.5 cm.) and the average diameter of the primary lesions was
3.3 cm.

Causative Factors. An analysis of the causative factors in the
present series fails to reveal any marked variation between cancer of
the gums and of other parts of the oral cavity except that the per-
centage of syphilis is not so high. The cumulative effect of several
forms of chronic irritation is obviously of more importance than the
action of any one irritant. The older mean age in the present series
may be simply fortuitous, or it may indicate that gingival cancer
develops only after long continued chronic irritation. Neither
syphilis nor tobacco appears to be an important factor in the present
series. In animals the high relative incidence of cancer of the gums as
compared to cancer of other parts of the oral cavity might provide
the basis for an interesting investigation—or at least speculation—on
the effect of differences in dietary habits in animals and in man. This
question, however, is beyond the scope of the present report.

Tobacco. As with all forms of intra-oral cancer which have been
analyzed at the Memorial Hospital, about 70 per cent of the patients
with gingival cancer give a history of using tobacco. This figure
approximates the incidence of the habit in the general male popula-
tion, and therefore is of little etiologic significance. Edling,[5] of Lund,
Sweden, reported a large proportion of tobacco-chewing farmers
among his cases of gingival cancer, but the chewing habit does not
appear to be common in New York City or the eastern United
States, since at the Memorial Hospital the coincidence of tobacco
chewing and intra-oral cancer is rare.

Syphilis. In ninety cases of the present series in which Wasser-
mann tests were made as part of the routine examination, positive
reactions were obtained in only 3 per cent, a figure which is below
that for syphilis in the average male population of the corresponding
age group (6 per cent).[30] The fact that it is below the average is

probably only accidental, but at any rate the low figure undoubtedly indicates that syphilis is not a factor in the causation of gingival cancer.

Dental Derangements. A causal relationship between dental derangements and cancer of the gums is undoubtedly more apparent than real. In the first place, if teeth were not present at the site of the growth, there would necessarily be a history of dental defects which led to extraction. Second, if teeth were present when the growth appeared, the patient would naturally believe that the trouble was of dental origin. Third, if the patient wore any form of denture, it would necessarily become ill-fitting in the presence of an underlying gingival tumor, and in such cases a direct causal relationship, even though erroneous, would always be assumed. For these reasons, a history of past or present dental complications can be obtained in most cases, but in the majority their significance is doubtful. In the present series about 25 per cent of the patients first consulted a dentist, and 15 per cent had had teeth extracted during the three months before admission to our clinic. An additional 10 per cent had attributed the development of the growth to ill-fitting dentures. Kirkham[14] reports that in practically all of his cases an erroneous diagnosis of dental abscess had been made before admission, and Gernez[9] states that almost all patients with gingival cancer first consult a dentist.

In pyorrhea alveolaris, primarily a disease of the peridental membrane in the tooth sockets, there is always an associated inflammation of the gums themselves. On the other hand, there are other forms of gingivitis, notably that associated with avitaminoses, which can occur independently of pyorrhea alveolaris. Any of these forms of chronic inflammation of the gums could conceivably be an important factor in the etiology of gingival cancer. However, some degree of gingivitis, probably from a combination of these causes, as evidenced by bleeding of the gums on brushing of the teeth, is almost universal. The manufacturers of tooth paste capitalize upon this fact in their advertisements. The gums and the dental apparatus are among the first structures to deteriorate with the natural aging process in both man and animals, and for this reason such changes cannot be considered as abnormal.

Acute abnormalities of the dental apparatus are self-limited in duration, since they are usually followed by early loss of the teeth and healing of the gums. From the mechanical standpoint, the gums

are not often affected by sharp or broken teeth which are likely to traumatize the border of the tongue or the mucosa of the cheeks. In the final analysis, one must conclude that although diseases and defects of the dental apparatus may possibly play a part in the origin of cancer of the gums, their significance is not great; and it is probable that the same extraneous irritants operate here to cause cancer as in other parts of the oral cavity.

SYMPTOMS, MORBID ANATOMY AND CLINICAL COURSE

The most common first symptom noted by the patients in the present series was the lesion itself (70 per cent), with local "soreness" occurring first in only about 20 per cent. Since the gums themselves are poorly supplied with nerves, pain or discomfort seldom occurs until the growth has extended to neighboring structures. In a few instances, the primary lesion produced no noticeable symptoms whatever, and the patients first consulted a physician because of enlarged cervical nodes (4 per cent).

A patient with cancer of the gum rarely seeks medical advice in the early stages of the disease. In the present series the average size of the growth was 3.3 cm. on admission. (Fig. 2.) In over one-third of the cases the primary lesion was over 4 cm. in diameter, and in only 10 per cent was it less than 2 cm. The average duration of symptoms before admission was 6.2 months.

The lesion begins as a small papillary ulcer, usually on the apex or margin of the gum (sometimes on the buccal surface separate from the margin, less often on the inner surface), which produces neither pain nor other discomfort. When first discovered by the patient, it is likely to be considered a dental abscess. If a tooth is extracted, the growth may progress by way of the tooth socket to invade bone. In other cases, as the tumor enlarges it may interfere with the fit of a dental plate or removable bridge, and the patient, mistaking the effect for the cause, believes that the denture has provoked the lesion. Unless the growth invades the underlying bone through the tooth sockets following extraction, the periosteum proves resistant for some time, and the tumor spreads peripherally into the cheek, hard palate, or floor of the mouth to form a broad, flat, superficial ulcer several centimeters in diameter. In other cases, especially in tumors of lower grade, the periosteum resists invasion and the growth fungates into the mouth.

After a period of several months the periosteum is finally perforated, and then bone is rapidly invaded and eroded. With deep invasion of the mandible, pathologic fracture may result. A growth

Fig. 2. W. S., age sixty-one, admitted to the Memorial Hospital in 1935. A, the primary lesion, about 3.5 cm. in diameter, involved practically the entire right gum. Diagrammatic insert shows extent of lesion. Biopsy showed squamous carcinoma grade 1. B, treatment was by peroral x-radiation. The patient has survived five years free of disease.

in the lower gum may extend through the bone to the skin over the outer surface of the mandible or the submaxillary region. Such deep invasion of bone is usually associated with sepsis, both locally and in the submaxillary nodes, so that there is a combination of inflammatory hyperplasia, local cellulitis and metastatic invasion of the submaxillary and upper deep cervical nodes. A combination of these various disease processes makes it difficult to determine the extent of the cancer.

Extension of the Growth. In the present series the disease had extended beyond the gum into the neighboring structures on admission in 90 per cent of the cases. The mucosa and deep tissues of the cheek (Fig. 3) were the most frequently invaded, with the hard and soft palates, the floor of the mouth and one anterior tonsillar pillar next in order. In most instances, more than one of these structures were involved. In 35 per cent of the present cases bone erosion was demonstrable both clinically and roentgenographically on admission. When the growth has once invaded the medulla of the mandible,

it may then progress for several cm. before again appearing on the surface.*

In the upper gum erosion of the maxilla eventually results in

FIG. 3. A. K., age sixty-seven, admitted to the Memorial Hospital in 1933. A, the primary lesion of the right lower gum had deeply invaded the gingivo-buccal gutter and perforated onto the skin surface. Diagrammatic insert shows extent of lesion. Biopsy showed squamous carcinoma grade 1. B, treatment was by a combination of x-radiation and radon seeds with com-plete regression. The patient later developed two separate primary cancers of the mucosa of the cheek and of the hard palate, which were excised by cautery.

extension of the disease into the maxillary antrum or nasal cavity. Invasion of the antrum, although almost always associated with purulent infection, seldom leads to marked swelling of the cheek and edema of the periorbital tissues, because the antral wall has been eroded and neither tumor nor pus can produce marked pressure within the cavity. From the anatomic standpoint this observation may be of some value in the differential diagnosis of doubtful cases. After posteriorly situated lesions of the upper gum have invaded the soft palate and cheek, there is sepsis in the region of the pterygoid and temporal tendons, and late in the course of the disease there may be swelling of the entire cheek and temporal region.

* In a recent case I have observed epidermoid carcinoma of the gum which invaded through the socket of an extracted left lower bicuspid tooth and progressed through the medulla of the mandible toward the right, crossed the midline, and then perforated the cortex to appear on the outer surface of the right lower gum opposite the right first molar. This continuous direct extension through the medullary cavity for a distance of about 6 cm. was proved both by roentgenographic examination and by gross and microscopic examination of the surgical specimen of the excised mandible.

Metastasis. In general, the behavior of metastasis in cancer of the gums follows that of other intra-oral cancers. About 35 per cent of the patients in the present series had cervical metastases on admission, which is about the same as the figure reported by Janeway[12] over twenty years ago. An additional 20 per cent developed metastases subsequently, so that 55 per cent had metastatic involvement at some time during the course of the disease, a figure which is only slightly lower than in cancer of the tongue and of the floor of the mouth. In the upper gum, metastases on admission (28 per cent) were less frequent than in the lower (39 per cent), although eventually 61 per cent of the growths of the upper gum metastasized as compared to 51 per cent of the lower. These figures are based upon too small a series to be absolutely conclusive, but in any case they do not confirm the statements of MacFee[15] and Schley[28] that metastasis to the cervical lymph-nodes from cancer of the upper jaw is infrequent.

The pathway of lymphatic drainage and the position of the nodes first involved vary considerably in cancer of the upper and lower gums, respectively. The difference may be adequately explained by the anatomy of the lymphatics, which has already been described. In the upper gum the lymphatic drainage is chiefly to the subdigastric nodes of the internal jugular chain which were involved first in the present series in over half of the cases with metastasis from this area. In a lesser number (39 per cent) metastases from the upper gum appeared first in the pre- and retrovascular nodes of the submaxillary group.

From the lower gum the main drainage is into the submaxillary group (preglandular, pre- and retrovascular) where nodes were involved first in about 65 per cent of the cases with metastasis from this area, with only about 30 per cent occurring first in the subdigastric region. The pre- and retrovascular lymph-nodes lie very close to the primary lesion in cancer of the posterior lower gum, and in advanced cases the two foci of the growth tend to coalesce and invade jointly the adjacent tissues. After involvement of the first "echelon," the disease disseminates to the middle and lower nodes of the jugular chain and to the viscera. Bilateral metastases occurred in only about 4 per cent of the entire series. Johnson,[13] reporting upon 122 cases from the Memorial Hospital clinic in 1925, recorded only one instance of bilateral involvement.

Systemic Metastases. In the autopsy records at the Memorial Hospital there are reports of 284 patients dead of cancer of the upper

respiratory and alimentary tracts. Among these are fourteen cases of gingival cancer, in five of which (35.7 per cent) there was visceral involvement. From these records it appears that visceral dissemination occurs more frequently from cancer of the gum than from cancer of any other part of the oral cavity except the mucosa of the cheek (36.3 per cent).

Double Primaries. As in other anatomic forms of intra-oral cancer, the coincidence of a second primary cancer in another site is not unusual. Multiple cancers occurred in eight of the present series, in one of which there was a separate growth of the gum on the opposite side. In the others the second cancers occurred, respectively, in the skin of the face, tongue, prostate, soft palate, pancreas, breast and sigmoid.

Cause of Death. The terminal symptoms in cancer of the upper gum are about the same as in cancer of the antrum. In cancer of the lower gum, the floor of the mouth and the tongue are invaded, with metastasis or sepsis in the submaxillary lymph-nodes, terminating in cellulitis of the whole submaxillary region. Death ensues from a combination of causes—exhaustion from pain, sepsis, malnutrition, and hemorrhage from the eroded external maxillary and/or mandibular arteries. It is probable that systemic metastasis is more often a factor in causing death than is commonly realized.

Melanoma. Melanoma occurs more often in the gums than in any other part of the oral cavity. In the present series there were four cases, two on the upper gum and two on the lower. One occurred in a male and three in females. The average age was forty-five years, about seventeen years younger than the average for carcinomas (sixty-two years). The average duration of symptoms in these cases was eleven months, five months longer than in the carcinomas.

The clinical appearance of mucous membrane melanoma is fairly characteristic. All of the four tumors were deeply pigmented, smoothly granular and ovoid, tending to fungate from the surface rather than to infiltrate deeply. Except for the pigmentation, they resembled the benign giant cell epulis in appearance. All of the growths metastasized first to the submaxillary lymph-nodes, then widely throughout the neck and eventually systemically. In one case which occurred in a female of forty years, the patient survived without recurrence for four years, when she developed metastases in the lungs and pleura, as shown both by her symptoms and roentgen examination of the chest. She survived the pulmonary metastases for

about fifteen months, during which time she coughed up from the bronchi a mass of granular tissue which was examined histologically and found to be melanoma. All of the cases terminated fatally despite treatment, with an average survival of almost five years, two patients living more than five years.

HISTOPATHOLOGY

Epidermoid carcinomas made up almost 90 per cent of the cases of gingival cancer in the present series, as shown in Table I, with squamous carcinomas, grade II, predominating (62 per cent). As in the lip and cheek, squamous carcinomas, grades III and IV, were rare. Adenocarcinomas arising in minor salivary glands made up about

TABLE I

HISTOPATHOLOGY IN 113 CASES OF CANCER OF THE GUM AT THE MEMORIAL HOSPITAL

Squamous carcinoma grade I	29
Squamous carcinoma grade II	66
Squamous carcinoma grade III	1
Melanoma	4
Lymphoepithelioma	1
Spindle cell carcinoma	1
Adenocarcinoma	5
Lymphosarcoma	1
No disease at primary site on admission	5
	—
Total	113

5 per cent of the cases, with lymphoepitheliomas occurring only occasionally. There were four cases of melanoma in the present series. As already stated, this tumor occurs more commonly in the gum than in any other part of the mouth.

DIAGNOSIS

A biopsy is an essential part of the management of intra-oral cancer, and a specimen should be taken in all cases from any suspicious ulcerated lesion in the mouth at the time of the first examination. Such confirmation of the diagnosis should be mandatory before the patient is subjected to the necessarily aggressive treatment for cancer, either radiologic or surgical, and no claim should be made for cure in cases which are not histologically proved.

Benign tumors which may be confused with cancer, or vice versa, are common in the gums. Their comparative incidence is shown in Table II. In general, their clinical appearance should immediately

suggest their benign nature, but since errors are so frequently made, they will be discussed in detail under separate headings.

Malignant tumors... 108
  Carcinoma...................................... 103
  Melanoma.. 4
  Lymphosarcoma.. 1
Benign tumors.. 67
  Giant cell epulis.... 29
  Granulation tissue epulis....................... 23
  Fibrous epulis.. 12
  Miscellaneous (papilloma, myxofibroma, angioma)........... 3

Delay in Diagnosis. At least one-fourth of the patients with gingival cancer first consult a dentist under the impression that the lesion is a dental abscess, commonly known as a "gum boil." In most instances the dentist extracts one or more teeth, whether or not he recognizes the true nature of the condition. Such errors obviously should occur only in the small or moderate-sized lesions, for the malignant nature of the ulcerated and fungating tumors can hardly be missed. Twenty-three patients in the present series (20 per cent) stated definitely that they had first consulted a dentist. In seven of these the dentist suspected that the lesion was a malignant growth and recommended medical consultation. In sixteen of the cases it is obvious that the dentist missed the diagnosis because teeth were extracted or mouth washes prescribed, and in these cases there was an average delay of 6.4 months before a correct diagnosis was made. Fifty-three patients (about 50 per cent) stated that they had consulted a physician first. In thirty-six of these a tentative diagnosis was made and the proper treatment advised. In seventeen it is apparent that the physician did not suspect cancer because the patients were treated with topical applications and mouth washes for varying periods. No average period of delay can be calculated because the patients' statements concerning the time interval were too indefinite.

Dental Abscess or "Gum Boil." This lesion is apparently common in dental practice and is the most frequently confused with cancer when the patient consults a dentist. A dental abscess is always a mound-like, painful swelling of the gums opposite a tooth. Fluctuation and acute tenderness are characteristic, and there is no

ulceration unless the abscess has ruptured or the gum has been incised. By contrast, cancer of the gum is always ulcerated from the beginning and is never painful or tender until the later stages.

Giant Cell Epulis. The most common benign tumor of the gums is giant cell epulis, an infectious granuloma of long duration in which inflammatory giant cells have formed. Giant cell epulis usually occurs as a deep bluish-red, ovoid, partly pedunculated tumor, usually on the outer surface of the gingival margin in close association with a tooth or sometimes in an edentulous gum. The surface may be covered with thin mucous membrane or it may be partly ulcerated, but there is never erosion. The history is usually of several months' duration with no symptom except the presence of the tumor. As long as the growth is not ulcerated, there appears to be considerable growth restraint; but following incomplete removal, there is rapid recurrence from the base. The treatment is local removal with curette and thorough cauterization of the base. It is usually necessary to extract one or more adjacent teeth in order to obtain complete destruction of the base of the tumor.

Granulation Tissue Epulis and "Pregnancy Tumor" of the Gums. Granulation tissue epulidi may appear in either sex and are usually associated with peridental sepsis. They almost always arise on the outer surface of the margin of the gum at its junction with a tooth and may be distinguished from cancer by the history and the characteristic deep-red, granular, pedunculated, non-infiltrating appearance. This lesion is fairly common during pregnancy when it is known as a "pregnancy tumor" of the gum. Exuberant granulomas of the gum are occasionally a feature of the gingivitis which accompanies avitaminosis B. The treatment is the same as for giant cell epulis. Most cases are benefited by the administration of vitamin B.

Fibrous Epulis. This tumor, usually associated with a tooth, appears as a firm pedunculated mass, 3 to 10 mm. in diameter, at the gum margin. The surface is covered by mucous membrane of normal color, and the growth apparently represents a granulation tissue epulis which has become organized. The tumor occurs more commonly in females than in males and is usually situated anteriorly on the outer surface of either the upper or lower gum. The treatment is local surgical removal with moderate cauterization of the base. There is no marked tendency toward recurrence.

Leukemia. The gums are occasionally the site of the first objective lesion in lymphatic or aleukemic leukemia, although the patients

complain mainly of loss of strength. In these cases the gums are swollen, bluish-red in color, and present granulomas of varying size at the margin. Biopsies from these areas may give a picture of lymphosarcoma, but the true character of the disease is shown by a blood count which will reveal the lymphocytosis. Several such cases have been observed at the Memorial Hospital.

Syphilis. The only syphilitic lesion which might simulate cancer in appearance is gumma. Although this lesion can theoretically appear in the gum, there is no case on record at the Memorial Hospital. It cannot be differentiated clinically from cancer, but it is so rare as to be of no diagnostic significance and should not be included in any theoretical considerations, provided that a biopsy is part of every routine examination.

Miscellaneous Benign Tumors. Papilloma, a benign warty epithelial tumor, may occur in any part of the oral mucous membrane. The treatment depends on the individual characteristics of each case and may be either by narrow surgical excision or by superficial cautery. Myxofibroma, hemangiomas and lymphangiomas may occur in the gums but offer no particular problem in diagnosis.

TREATMENT OF THE PRIMARY LESION IN CANCER OF THE GUM

The effectiveness of any form of treatment of cancer of the gum (surgery, cautery or radiation) is dependent upon certain anatomic features which are unique in the gums and hard palate. Growths in these areas arise in a thin layer (1 to 2 mm.) of soft tissue overlying bone. Whether or not the periosteum has been invaded, adequate surgical treatment requires the removal of at least a thin shell of the underlying bone; otherwise there is no assurance that the base of the growth has been removed. In the upper gum, the removal of overlying bone usually means opening into the antrum and sometimes the nasal cavity. This portion of the bone, so near the surface, also limits the possibilities of radiation therapy. In many cases the thinness of the growth over bone makes the retention of interstitial implants impossible or at least uncertain, and therefore the dependence must be placed chiefly upon external radiation. The administration of cancer lethal radiation doses in gingival cancer will at least partially devitalize the underlying bone, subjecting considerable areas to the danger of subsequent radio-osteomyelitis. If the periosteum and bone have been invaded, sterilization of the growth will

inevitably leave the bone exposed, radio-osteomyelitis follows, and sequestration of the bone must take place before healing.

The treatment method in the individual case of gingival cancer should be selected after a full consideration of these limitations and complications. In carcinoma, which makes up over 95 per cent of the malignant tumors of the gum, no single method is suitable in all cases. Radiation, surgery and combinations of the two all have a definite place in the treatment of this disease. In two of the rare histologic types, the indications in the selection of the treatment method are more definite; that is, melanoma should be treated only by surgical excision and lymphosarcoma only by radiation.

In the literature most of the references to gingival cancer are found in articles on cancer of the upper and lower "jaw," and they frequently include antral or bone tumors in the same group. As has already been mentioned, so-called "carcinomas of the jaws" are often grouped with growths of the floor of the mouth, cheek or tongue, and the data are therefore confusing. When the pertinent opinions regarding treatment of gingival cancer are sifted out, they are found to be about equally divided between local excision of the tumor by actual cautery (Crile,[4] Bloodgood,[3] Ochsner[22]) or endothermy (Gernez,[9] Ohngren,[23] Fischel[6]), radiation methods (Johnson,[13] Quick,[25] Ashbury,[2] Janeway[12]), radical resection of the maxilla (MacFee,[15] Meyer,[21] Woodman,[31] Schley,[28] Frenckner,[7] Harmer[10]) and combinations of surgical excision and radiation (Edling,[6] Maurel[20]). Many of the total resections of the upper jaw have probably been done for reasons similar to those for amputation of the extremities at so-called "sites of election." Such a principle is not well conceived when applied to the maxilla, for a line of resection passing through the nasal cavity and the orbit can hardly be considered a "site of election." As far as the comparative merits of any single one of these methods is concerned, one can find no proof in the literature, since none of these authors has given five-year end results on a series of histologically proved cases.

General Hygienic Measures. As in all forms of intra-oral cancer, hygienic care of the oral cavity both before and during treatment is an important factor in a successful result. In the uncomplicated case, local sepsis is superficial and can be controlled by mouth irrigations (q. 2 to 3 hr.) with alkaline-saline solutions (sodium bicarbonate and sodium chloride aa ʒi to 1 quart of warm water) and cleansing by power sprays (2 to 3 times a day).

The presence of teeth directly at the site of the primary growth or in the immediate vicinity always constitutes an obstacle not only to the administration of treatment but also to proper hygienic care. The solution of this problem must be individualized in each case. Wholesale extraction of teeth is objectionable for several reasons. First, laceration of the gum opens the tooth sockets to invasion by the growth or by infection following radiation. Moreover, if there is an eventual loss of bone in either the upper or lower jaws, the retention of some sound teeth is invaluable if restorations by mechanical prosthetic appliances are to be used. A few teeth may have to be extracted so as to permit the introduction of the proper sized cylinder for peroral x-radiation. Other teeth may be so loose and so involved by dental sepsis that extraction is necessary even though objectionable from some standpoints. In other instances, sound teeth are best amputated at the gum margin, the nerve extracted and the root canals filled, leaving the tooth sockets plugged to guard against invasion by growth or infection.

As with many forms of intra-oral cancer, dietary deficiencies, especially avitaminosis B, accompanied by low grade stomatitis may play an important rôle in the etiology and treatment of cancer of the gum. The malnutrition associated with this condition can be greatly improved by the administration of large doses of the vitamin B complex as, for instance, dried granular yeast in doses of three tablespoonsful (50 Gm.) daily.

Treatment of the Primary Lesion by Radiation. Although there may be definite advantages in surgical removal of the smaller lesions, the fact remains that radiation therapy is the most useful and suitable method of treatment, since in the average case the growth in the gum is situated posteriorly, is over 3 cm. in diameter and involves at least one neighboring relatively inoperable structure. In superficial growths arising in the thin layers of soft tissue overlying bone, external rather than interstitial radiation must be the main form of treatment. Quick[25] has called attention to the mechanical impossibility of deep implantation of interstitial sources and the inadequacy of contact application of radium in cancer of the gum.

At the Memorial Hospital the radiation technic for cancer of the gum consists of (1) peroral x-radiation given through the open mouth by the use of metal cylinders, thus avoiding irradiation of the overlying skin, cheeks and lips; (2) supplementary x-radiation through accurately centered portals on the skin of the cheek, the tongue and

the opposite side of the mouth being at least partly protected by lead shields placed on the lingual surface of the affected gum; (3) supplementary implantation of small doses of radon seeds in residual disease
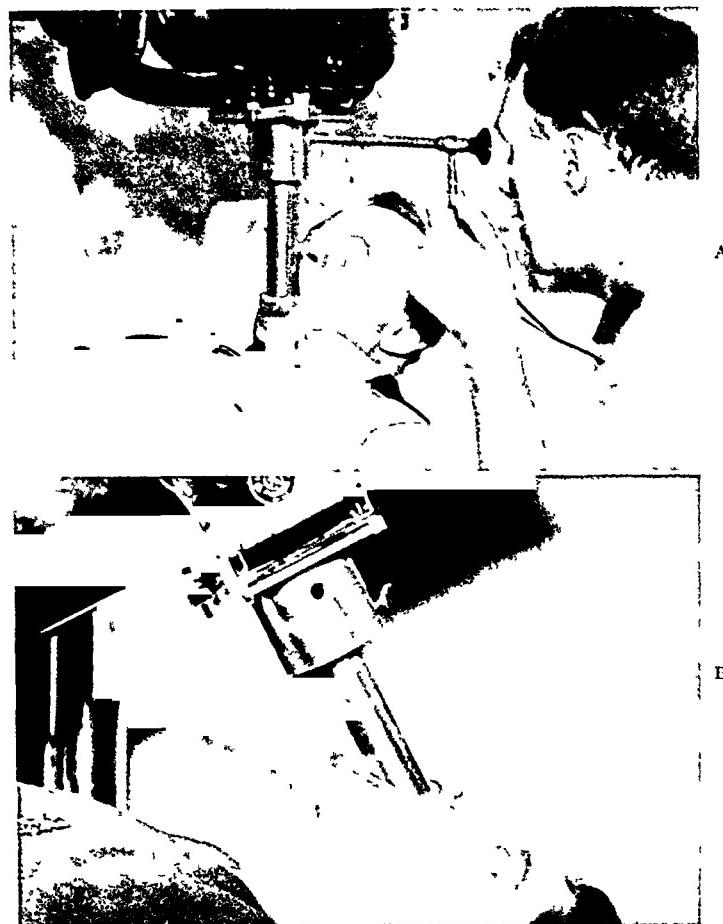
FIG. 4. A, a patient is shown in position for peroral x-radiation to a cancer of the lower anterior gum. The surgeon checks the accuracy of the set-up by an electrically lighted periscope, following which the periscope is removed and the treatment administered. B, peroral x-radiation for a growth of the upper gum.

in the cheeks or floor of the mouth or, rarely, in the gums themselves. The use of supplementary contact applications of radon in dental compound molds is useful only in rare instances.

After the preliminary extraction or amputation of such teeth as constitute a definite obstacle, peroral x-radiation is given through a metal cylinder of the correct size (2.5 to 5 cm. in diameter) to include the primary lesion amply with a margin of at least 1 cm. of surrounding normal tissue if possible. (Fig. 4.) A detailed description of the apparatus and of the advantages of this technic has already been

published.[16] Accurate direction of the beam and centering of the peroral portal is favored by the use of an electrically lighted periscope. (Fig. 4.) For the peroral x-radiation of intra-oral cancer we have used both high voltage x-ray (200 to 250 kv., filter 0.5 to 1.5 mm. Cu) and low voltage x-ray (100 to 120 kv., no filter except the tube wall, 1 mm. Al eq.) at the shortest target skin distance (15 to 35 cm.) which can be obtained within the mechanical limitations of the apparatus. The treatments are given daily or at least three times a week. The individual dose in roentgens depends upon the correlation of such physical factors as the voltage, the size of the portal and the frequency of the treatments. On an average the total dose in about twenty to twenty-five days with high voltage radiation (200 to 250 kv.) is from 5,000 to 7,000 r; with low voltage radiation (100 to 120 kv.) the total dose over the same period is 10,000 to 15,000 r.

In most cases peroral x-radiation to the gum as described above is combined with external radiation given through the skin of the cheek, the exact center of the portal being carefully determined and marked on the skin by a small tattoo mark.* Treatments are given to the two ports on alternate days, the daily dose depending on the size of each portal. The external portal should be kept to a minimum size (3.5 to 5 cm. in diameter), just large enough to cover the primary lesion with a margin of about 1 cm. A total dose of 4,000 to 5,000 r is given to this portal over a period of three weeks. At the completion of this x-radiation, subsequent treatment depends upon the amount of reaction in the normal tissues and the regression of the tumor. In some instances further external radiation may be given. If only a small nodule of residual disease can be palpated in the margin, it is often best to implant a few radon seeds (2 to 5 of 1 mc. each). In rare instances contact application of radon in dental molds might be used after x-radiation.

Treatment of the Primary Lesion by Surgery. As has been mentioned previously, it is best to restrict purely surgical removal to small superficial tumors which have not extended into neighboring structures. The technic for the combined use of cautery and bone chisel in these lesions is described in Figures 5 and 6 with their

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* The skin is cleansed with alcohol and a small drop of India ink is placed at the selected point. With a sterile, sharp-pointed surgical needle, several punctures are made through the India ink into the skin. Such a mark remains permanently, but its size can be so small as to be unobjectionable.
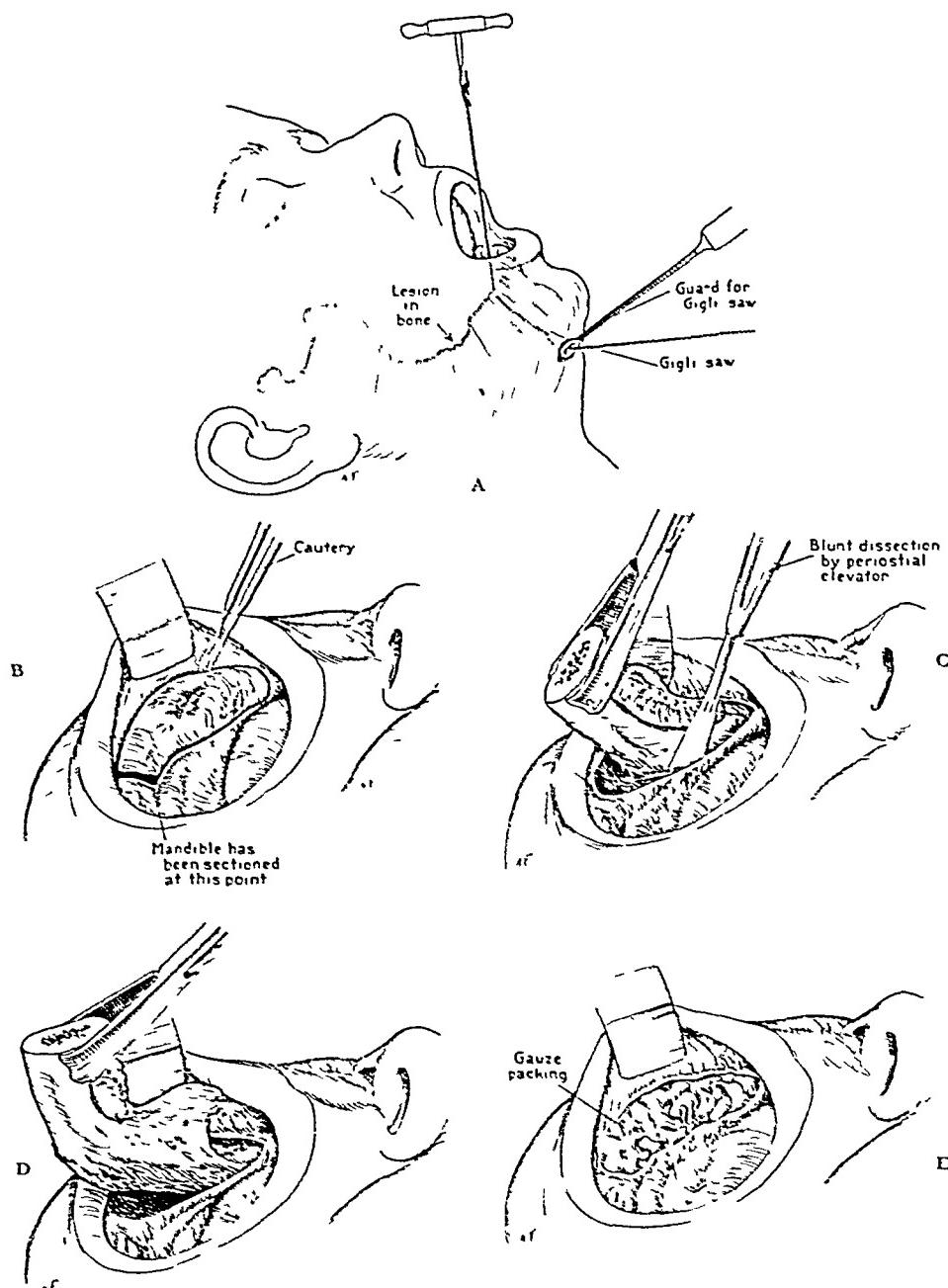
FIG. 5. A, B, C, D and E, *resection of the mandible through the mouth*. A, the mandible is usually sectioned near the symphysis, preferably with a Gigli saw inserted through stab wounds from the floor of the mouth out through the skin of the submental region. The skin is advantageously protected by a specially devised guard. B, after the mandible is sectioned, the mucous membrane surrounding the lesion in the gum is cut through by an actual cautery, leaving a safely wide margin of normal tissue. C, the bone is grasped by a bone-holding forceps and freed by sharp and blunt dissection. D, the attachment of the temporal muscle to the choronoid process is severed and the temporomandibular joint disarticulated by torsion. E, hemorrhage is controlled mainly by packing and the wound is left open.
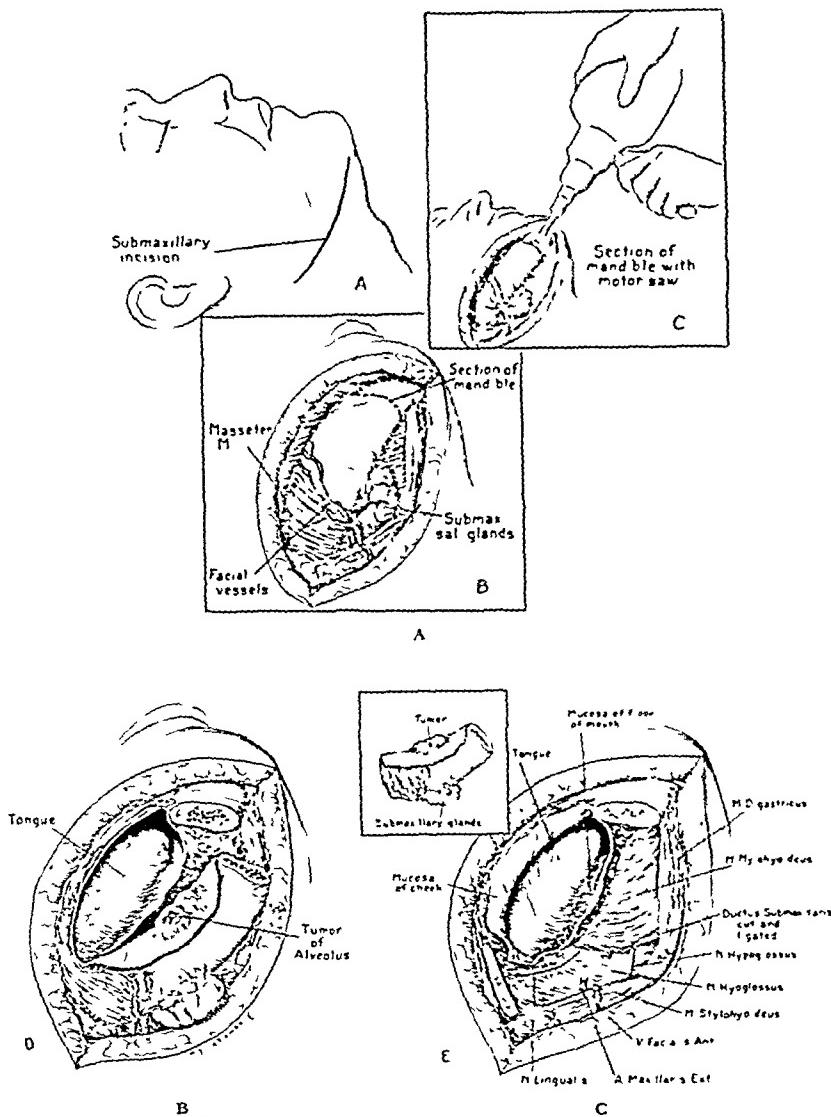
Fig. 6. A, B, c and D, *resection of the mandible through an external incision.* A,
after exposure of the outer surface of the mandible through an external
incision (A and B), the bone is sectioned by a motor saw (C). B, after section
of the bone, the oral cavity is entered by an incision placed sufficiently wide
of the tumor, as inspected through the open mouth. c, after incision through
the soft tissues safely wide of the lesion, the bone is again sectioned near
the angle by a motor saw and the bone fragment removed with the contents
of the submaxillary triangle (submaxillary salivary gland and lymph-
nodes). The ascending ramus of the mandible may also be sectioned by
disarticulating at the temporomandibular joint. D, the operative wound
is closed in layers, the mucous membrane by an inversion stitch (F and G)
reinforced by a layer of muscle sutures (H and I), and finally the skin is
closed with provision for subcutaneous drainage (J).

accompanying legends. These more extensive operations should be preceded by ligation of at least one external carotid artery.

In the upper gum this technic may be used to excise the larger

Closure of second layer by catgut sutures

H

F

Closure of mucosa by inversion stitch

J

G

Mucosal closure complete

I

Ends of bone fragments buried by approximation of soft tissues

D
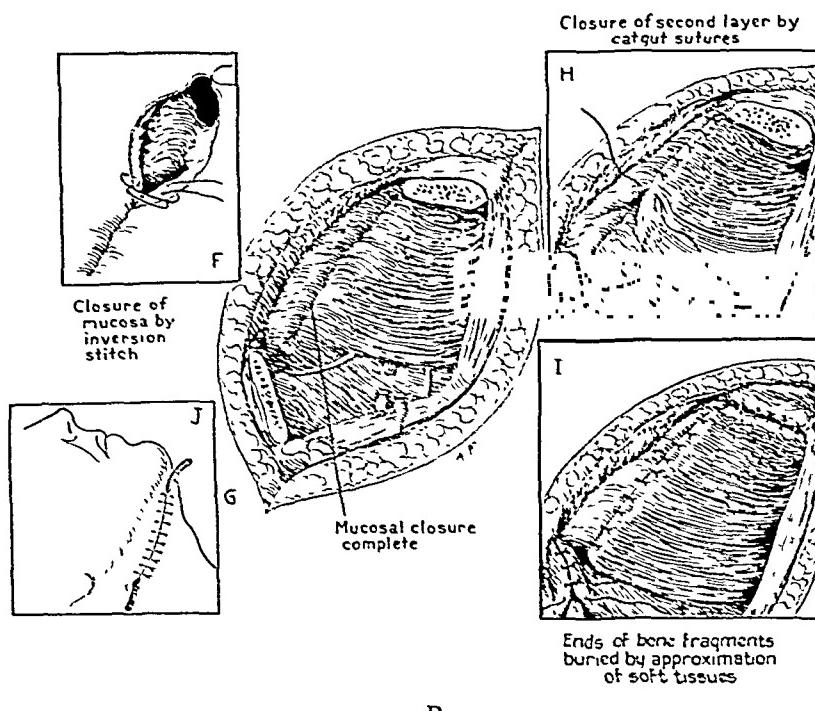
For descriptive legend see opposite page.

portion of the maxilla including the floor of the antrum. As far as cancer of the gums is concerned, such an operation is just as effective as total resection of the maxilla with the additional advantage that neither the uninvolved floor of the orbit nor the lateral wall of the nasal cavity is disturbed.

In the lower gum the possibilities of local surgical removal are somewhat less than in the upper gum, for unless the volume of resected bone is small, it is impossible to maintain the continuity of the mandibular arch. When a portion of this bone is removed, the deformity is extensive and the function of mastication is permanently lost. Partial or hemiresection of the mandible is sometimes indicated for persistent or recurrent cancer or for radio-osteomyelitis. If a posterior portion of the horizontal ramus is to be excised, a better cosmetic result is obtained by including the ascending ramus in the resection, disarticulating it at the temporomandibular joint (Fig. 6c); otherwise, the fragment of the ascending ramus tends to be drawn forward and upward into the oral cavity and, after healing,

constitutes a minor nuisance. When the mandible is resected for cancer, the line of incision passing through soft tissues must be determined by the probable extent of the growth. In these cases it is usually advisable to make an external incision through the skin. When the mandible is resected for radio-osteomyelitis alone, the dissection is subperiosteal through the open mouth. When resection of one mandible is contemplated and teeth are present in the uninvolved side of the mouth, arrangements should be made to wire the jaws together at the time of the operation so as to avoid distortion during the healing process. Such a precaution makes it much easier to construct prosthetic appliances.

Melanomas of the gums should always be treated surgically since this tumor is as radioresistant as normal tissue. In spite of its malignancy, melanoma does not tend to recur locally after removal with an average margin of normal tissue, so that an extremely radical excision gives no greater assurance of cure. The choice between local removal and more extensive excision of the maxilla or mandible should be based upon the size and extent of the local tumor.

Combinations of Surgery and Radiation. In selected instances, bulky infected tumors in the upper and lower gums not suitable to either radiation or surgery alone may be treated by a combination of the two, first applying radiation (x-ray plus interstitial radon) in what is believed to be a cancer lethal dose, followed immediately by a débridement of the heavily irradiated and condemned tissue which would otherwise undergo massive radionecrosis. The dosage technic under such a plan is extremely variable and must be individualized.

In the present series the method of treatment giving the highest percentage of success was a combination of peroral x-radiation supplemented by implantation of radon seeds, although in only a slightly lesser number x-radiation alone, perorally and externally, was successful. Cautery methods used either alone or in conjunction with radiation were successful in selected instances.

TREATMENT OF METASTASES IN CANCER OF THE GUM

Prophylactic Treatment. One of the most controversial aspects in the treatment of cervical metastases from any form of intra-oral cancer is the management of those cases in which metastases are not clinically demonstrable in the cervical lymph-nodes. There are three prevailing opinions: (1) The older surgical concept is that metastases

are present in the majority even though they cannot be palpated, and therefore block dissection should be performed in all cases. Some surgeons also advise the administration of postoperative radiation. (2) The more recent radiologic concept holds that only prophylactic radiation should be given in these cases. The dosage which has been advised varies from 1 to 2 skin erythema doses upward, although few advise the administration of dosages which have been proved lethal for demonstrable cancer. (3) The watchful-waiting policy is based upon the theory of treating cancer only where it is demonstrably present. In the latter case the surgeon assumes full responsibility for systematic follow-up with the intention of giving aggressive treatment (surgical, radiologic or combinations of the two) only when there is actual clinical evidence of metastases. A full discussion of the comparative merits of these three plans is beyond the scope of the present paper and has already been published in previous reports.[24]

The policy in the Head and Neck Clinic of the Memorial Hospital may be summarized briefly as follows: (1) Prophylactic neck dissection (an operation performed in the absence of clinically demonstrable metastases) is a tedious procedure attended by a morbidity of two to three weeks and a definite though small mortality even in experienced hands. Statistics will prove that this operation, when performed in the absence of clinically involved nodes, will be of actual value in too small a number of cases to be justified. If it is conceded that its benefit is limited to the cases of those patients who are first seen without cervical metastases in whom the primary lesion is permanently controlled and who later develop metastases, it would be useful in only one in thirty-five cases of cancer of the lip, one in eight cases of cancer of the tongue, and one in four cases of cancer of the gum. In some of these forms of cancer the operative mortality far exceeds the possible salvage. Although there is a comparatively greater risk of developing cervical metastases in cancer of the gum than in these other forms, prophylactic neck dissection is nevertheless still objectionable since it is attended by a greater risk of exposing the irradiated or surgically scarred areas within the mouth to such complications as osteomyelitis or a break-through with infection. (2) The case for prophylactic radiation is even less tenable. The critical observer realizes that the complete eradication of cancer by radiation depends upon giving a lethal dose and that no permanent benefit is to be derived from less than a lethal dose of radiation.

The lethal dose for epidermoid carcinoma has been proved to be at least 5 to 6 skin erythema doses.[18] Such a dose of radiation to the entire area of the neck in which metastases might occur is attended by marked disability and is often fatal. None of the proponents of prophylactic radiation to the neck advises giving cancer lethal doses to the entire neck. The administration of 1 to 2 skin erythema doses, a dose which has no visible effect upon the average epidermoid carcinoma, can hardly be called logical. (3) In view of the foregoing, the watchful-waiting policy seems the most reasonable from the theoretical standpoint. In brief this policy is as follows: If no metastases are clinically demonstrable at the time of admission, no treatment is given to the neck. The patient is examined at regular intervals (at least once a month for the first year). If clinical evidence of metastasis appears, aggressive treatment—either surgical or radiologic—is given, the choice depending upon the individual case. The actual merit of any plan of treatment depends upon the end results to be obtained both in the five-year end results in unselected groups and in the number and cures of proved metastases, as will be discussed further under subsequent headings.

Treatment of Clinically Demonstrable Metastases. The treatment of metastasis from the upper gum is essentially the same as in intra-oral cancer in general, since the nodes first involved are usually in the upper or subdigastric group of the internal jugular chain. In cancer of the lower gum, the mode of metastasis resembles that in cancer of the mucosa of the cheek, that is, the first involvement usually occurs to the pre- and retrovascular submaxillary nodes. In cancer of the posterior cheek or posterior lower gum, a rather unique situation occurs, that is, the first metastasis (pre- or retrovascular submaxillary node) is almost in direct contact with the primary lesion.

The treatment for metastasis from cancer of the upper gum depends mainly upon the time of the appearance of the metastases. If nodes are involved on admission, radiation is undoubtedly the most useful form of treatment. The technic for the radiation treatment of cervical metastatic cancer has been described in detail in previous reports from our clinic,[19] the most important factors being the administration of fractionated x-radiation through small portals (3 to 5 cm. in diameter) limited to the region of the node itself, giving a total of 5,000 to 8,000 r over a period of about three weeks (200 to 250 kv., 35 to 50 cm. T.S.D., 0.5–1.5 mm. Cu. filter), supple-

mented by the implantation of radon gold seeds either in a single dose or in fractions. In the present series, six patients with proved metastases, who were treated by radiation alone, have survived for more than five years.

In metastases from cancer of the lower gum the problem is influenced by the juxtaposition of the primary lesion and the pre- and retrovascular lymph-nodes. In peroral x-radiation of the primary, the beam can often be tilted so as to include both the metastases (in the pre- and retrovascular nodes) and the primary lesion. The x-radiation is supplemented by the implantation of radon seeds mainly in the lymph-node, thereby lessening to some extent the risk of radionecrosis and radio-osteomyelitis which are more likely to result if the seeds are implanted within the mouth. In posteriorly placed lesions of the lower gum with metastases to the submaxillary nodes, localized radio-osteomyelitis often occurs, but if the growth has been destroyed this complication can be treated conservatively until the bone sequestrates spontaneously.

For metastases which appear after healing of the primary lesion in the lower gum, the selection of treatment must be individualized, depending upon the amount of radiation scarring. Either surgery or radiation might be preferable in the individual case in an effort to favor prompt healing of the tissues. In certain complicated cases in which a metastatic node becomes attached to or invades the mandible, submaxillary dissection may be combined with resection of a portion of the mandible. In such cases the skin incision may be closed at the completion of the operation or, if large areas of skin must be removed, the wound may be left open for later plastic closure.

The present series of 113 cases is not large enough to permit any final conclusions in regard to the relative merits of radiation and surgery in the treatment of cervical metastases in cancer of the gum. Of the sixty-two patients with metastases, seven were selected as being suitable for neck dissection on the basis of apparent control of the primary lesion and the presence of early and operable metastases in the neck. All seven survived the operation but subsequently succumbed to recurrences in the neck (four cases), at the site of the primary lesion (two cases), or to systemic dissemination (one case). In the fifty-five remaining cases with lymph-node involvement, the metastases were considered inoperable or at least unsuitable for neck dissection, and treatment was by radiation alone. Six of these

patients with histologically proved metastases (aspiration biopsy) have survived for five years or more, as well as an additional three in whom the nodes were clinically positive although aspiration biopsies were omitted. The survival of at least six (about 11 per cent) for five years in comparison to no survivals by surgery is a strong indication that radiation is a more useful method than surgery in metastases from cancer of the gum. In any event, neck dissection, if used in gingival cancer, should be limited to those cases in which the primary lesion is under apparent control and the nodes occur late in the course of the disease. When nodes are present in the beginning, neck dissection can hardly be combined safely with the necessarily aggressive treatment (by either surgery or radiation) to the primary lesion.

In melanoma of the oral mucous membrane an exception might be made to the rule against prophylactic neck dissection, although it is doubtful whether the end results would be greatly influenced. As far as the Memorial Hospital cases are concerned, intra-oral melanoma invariably metastasizes so that it might be argued reasonably that a neck dissection is in order. On the other hand most of such metastases are bilateral and the systemic metastases which have also occurred in all of our cases indicate that dissemination takes place by way of the blood stream as well as by the lymph stream; therefore, neck dissection would be useless.

PROSTHETIC REPAIR OF DEFECTS OF THE MAXILLA, PALATE AND MANDIBLE

Adequate treatment of all forms of intra-oral cancer frequently necessitates a loss of the soft parts or bone and the production of both cosmetic and functional deformities. Defects of soft parts may often be repaired satisfactorily by plastic surgery; but if there has been a loss of bone of the jaws or palate, surgical repair or bone grafting is seldom practicable, and some mechanical contrivance is not only more effective but easier to apply. Dr. Andrew Ackerman, dental surgeon of the Memorial Hospital, has reported in considerable detail the forms and methods of construction of various mechanical devices for the repair of defects in the jaws and palate following treatment of cancer in the mouth.[1] In cancer of the gums, the deformities resulting from treatment are due almost entirely to loss of bone.

In the upper gum the defect, usually opening into the antrum and sometimes into the nasal cavity, produces a double disability. With large defects in this area speech is unintelligible since articulation is impaired and resonance altered. Furthermore, eating and drinking are difficult since part of the ingesta tends to enter the nasal cavity, to be expelled through the nose on swallowing. While surgical repair of these upper jaw and palatal defects is impractical, they may usually be almost perfectly remedied by prosthetic appliances so that normal function in both speech and swallowing is restored. Such devices consist mainly of a modified upper dental plate so shaped and fitted as to close tightly the opening in the palate and floor of the antrum. Firm retention is attained by a combination of several expedients, such as the usual suction cup, clasps on remaining teeth, and undercutting of the edges which fit into the defect. In the smaller defects, such prostheses can be made satisfactorily by the average dentist. When there is extensive loss of bone and soft tissue past the posterior border of the hard palate, the defects may be such as to require the services of a dentist with special training and experience in the construction of such appliances.

In the lower jaw any loss of substance involving a break in the continuity of the mandibular arch also produces both a cosmetic and functional deformity. Following the loss of the whole or of a portion of one horizontal ramus, the opposite mandible shifts toward the defective side, drawing the remaining teeth out of proper occlusion. Depending upon the amount of bone lost, and especially on whether the defect is situated anteriorly, the shape of the lower part of the face is distorted to a variable degree. When the anterior portions of both horizontal rami are lost, the normal contour of the chin is markedly altered, and the tongue, deprived of its anterior support, recedes backward and downward into the pharynx for a short distance. In addition to this cosmetic deformity the power of mastication is completely lost since the grinding of food by the molars is produced by a complicated vertical, horizontal, and lateral motion of the mandible by the combined action of two sets of temporal and pterygoid muscles. Even the simple biting action is impossible since the teeth can no longer be brought to proper occlusion. Despite these cosmetic and functional abnormalities, the loss of a portion of the mandible is compatible with perfect health, although the nature of the food must be altered.

In the repair of bone defects of the lower jaw, the interposition of a bone or cartilage graft from a rib or other bone is sometimes advised. Although such an operation is technically feasible if done immediately following partial resection of the mandible, it can seldom if ever be applied in cancer of the gums. Such bone or cartilage grafts, to be successful, must be embedded in healthy vascular soft parts in a sterile field. In surgical resection of the average gum cancer, the intra-oral wound cannot be sutured, and in any case would be grossly contaminated by infection. Following radiation the decreased vascularity of the tissues in the healed state would make the success of the bone grafting doubtful. Furthermore, in most cases after the treatment of cancer, the possibility of recurrence would make it prudent to wait for a year or two before any grafting were attempted, and by that time the scarring and contracture are so firm as to make restoration of the normal contour impossible, even if a sufficient thickness of soft tissue were present in which bone grafts might be embedded.

In the most marked deformities following partial loss of the mandible, there is no method of complete restoration. In certain instances, however, in which there is minimal scarring and not too great a loss of bone and soft tissue, Ackerman has succeeded in markedly improving both the appearance and the function by ingenious hinged devices attached to an upper denture. Although the ability to masticate has seldom been restored, such devices contribute a great deal to the patient's comfort and appearance.

<div style="text-align:center">COMPLICATIONS</div>

Radionecrosis and Osteomyelitis. As has been previously mentioned, the gum consists of a thin layer of soft tissue about 2 to 3 mm. in thickness overlying bone. The blood supply of the gum is entirely peripheral, coming from the adjacent cheek, palate or floor of the mouth. The thinness of the gum and the lack of a blood supply from its base make this structure particularly susceptible to local radionecrosis following cancer lethal radiation. Radiation in such dosage, which also reaches the underlying bone, is sufficient to destroy the finer osseous circulation, so that when bone is exposed by radionecrosis of the overlying gum, radio-osteomyelitis is almost inevitable. It is only by appreciation of these facts and by meticulous attention to the details of radiation technic that such complications can be avoided or their severity diminished. The most important

<div style="text-align:center">[30]</div>

precaution is the limitation of the portal or external radiation to the smallest efficient diameter and the accurate centering of the radiation beam.

In the present series there was radionecrosis of soft tissue in about 50 per cent of the cases, and at least half of these subsequently developed radio-osteomyelitis with some loss of bone. When superficial radionecrosis occurs with exposure of the underlying bone, the best treatment is conservative, combatting the sepsis with frequent irrigations and applying oxygenic preparations (zinc peroxide) over a period of weeks or even months until the bone finally sequestrates. The exposed fragment of bone may be manipulated gently from time to time in an attempt to hasten its separation. If local sepsis and pain attendant upon the osteomyelitis are particularly severe, partial resection of the bone in either the upper or lower jaws may be indicated. In such cases the line of resection should be through viable bone, which is possible only if the beam of external radiation has been limited in extent. When wide beams of 8 to 10 cm. in diameter are used, the radio-osteomyelitis usually progresses through the entire mandible or maxilla. The morbidity is long, and the complications often fatal.

Dental Complications. The extent to which the presence of teeth in either the upper or lower jaws is an obstacle to the administration of both surgical and radiologic treatment has already been mentioned. The complications which are likely to follow the extraction of teeth have also been described. When sound teeth are permitted to remain within the field of cancer lethal radiation, dental complications are inevitable. When the teeth and adjacent alveolar processes are irradiated in cancer lethal doses, the gums retract and the teeth are devitalized, probably as the result of a devitalization of the peridental membrane and the destruction of the apical circulation. Over a period of several months to a year, such teeth lose their normal gloss and assume a chalky appearance. Numerous cavities develop, not only on the occlusal surface but near the gum margins. The tooth structure crumbles away, and in some cases the entire exposed portion of the tooth disappears down to the gum margin, leaving a decalcified exposed root.

When teeth are extracted before treatment is begun, the granulation tissue in the tooth sockets tends to disappear under heavy irradiation, leaving avascular bone exposed. When teeth are extracted at an interval after heavy irradiation, the tooth sockets

may bleed very little, and granulation tissue may fail to develop. Osteomyelitis then occurs, beginning in the exposed bone. There is no way of eliminating these dental complications, but their extent and severity can be markedly reduced by meticulous attention to the details of radiation therapy and hygienic care.

Pain. As has been mentioned previously, pain is not a prominent early symptom in cancer of the gums, due mainly to the fact that these tissues are poorly supplied with nerves. Pain seldom becomes a marked symptom in cancer of the gums except after invasion and sepsis of the bone or of the soft tissues of the cheek, the floor of the mouth or the palate.

With osteomyelitis of the maxilla or mandible, it is mainly the superior and inferior dental nerves which are affected, and in these cases neurolysis of the second and third divisions of the fifth cranial nerves by alcohol may effect complete relief from pain provided that complications do not extend into the areas supplied by other nerves, such as the ninth or the upper cervical branches.

Hemorrhage. Following erosion by disease or radionecrosis, hemorrhage occurred as a complication in over 20 per cent of the present series and was the cause of death in six cases. It occurred most frequently in growths of the upper gum. The blood supply to the upper jaw is mainly from the internal maxillary artery, the larger branches of which lie rather deeply in the pterygotemporal fossa so that serious hemorrhage rarely occurs except when there is deep erosion following radionecrosis in this area. The blood supply of the lower jaw and adjacent soft parts is from the inferior dental, the external maxillary and the lingual branches of the external carotid arteries. Serious hemorrhage does not occur from the inferior dental artery which is relatively small in size. Deep erosion or slough in the floor of the mouth or in the gingivobuccal gutter may erode either the external maxillary or the lingual artery or both, and hemorrhage may be severe enough to be fatal immediately.

When bleeding occurs from any one of these vessels, the immediate treatment is by local tamponage with gauze packing and digital pressure, followed as soon as possible by ligation of the external carotid artery. Since in most cases the healing of the wound in the mouth may not take place for several months, the occlusion of the artery should be permanent, either by section of the vessel by double ligatures or, preferably, by the use of a metal ligature. When

bleeding occurs from the lower jaw, the ligature on the external carotid must be placed below the origin of the lingual artery.

PROGNOSIS

In the medical literature where specific reference is made to the subject, cancer of the gum is usually reported to have a bad prognosis.[11,14] At the Memorial Hospital the chance of cure in this group of tumors is slightly better than that in cancer of the tongue, floor of the mouth, or tonsil, and about the same as in cancer of the cheek. The factors influencing the chance of cure are given in Table III, the most important of which will be discussed separately.

Age. Although in most forms of intra-oral cancer the chance of cure is better in the younger age groups, an analysis of the present series gives little evidence in this regard. Although two of four patients (50%) under the age of forty were cured, but the number is too small to permit of any definite conclusions.

Sex. As in all forms of intra-oral cancer which we have studied in our clinic, an analysis of the present series indicates that the chance of cure of cancer of the gums is better in females (50 per cent) than in males (23 per cent). It is probable that this difference is due mainly to the fact that all anatomic and histologic forms of cancer are more radiosensitive in the female than are their counterparts in the male.

Position of the Growth. Although one might expect a difference in the cure rate between cancers of the upper and lower gum and between lesions near the symphysis and those situated posteriorly near the soft palate, there appears to be no significant variation in this regard.

Size of the Primary Growth. As might be expected, the size of the primary lesion on admission is one of the most important factors in the prognosis. When the growths were less than 2 cm. in diameter, the cure rate was 50 per cent, as compared to 13 per cent in those over 4 cm. The average size of the growths in all cases was 3.3 cm., in the fatal cases 3.5 cm., and in the cured cases 2.9 cm.

Metastases. In gingival growths, as in all forms of cancer, the occurrence of metastases is the most important factor in prognosis. Among patients with no metastases at any time, the five-year cure rate was almost 50 per cent, as compared to 11 per cent when metastases were present some time during the course of the disease. There were no survivals among the thirty-eight patients with metastases on

TABLE III

FACTORS INFLUENCING THE PROGNOSIS IN 105 DETERMINATE CASES OF CANCER OF THE GUM
AT THE MEMORIAL HOSPITAL

	Total Cases	Five-year Cures	Five-year Cure Rate
Age			
Under 40	4	2	50
40 to 49	10	2	20
50 to 59	21	7	30
60 and over	67	15	22
Not stated	3	1	
Sex			
Male .	85	19	22
Female	20	8	40
Position of the growth			
Right	44	14	32
Left	56	12	21
Both	2	0	0
Midline	3	1	33
Upper	47	12	25
Lower	57	15	26
Both	1	0	0
Size of lesion			
0 to 1.9 cm	8	3	38
2 to 2.9 cm	25	7	28
3 to 3.9 cm	16	5	31
4 cm. or over	35	6	17
Size not stated or scar present	21	6	29
Metastases			
On admission	38	0	0
None on admission	67	27	40
Cervical involvement later	17	6	35
Distant metastases later	7	0	0
Metastases sometime during course	62	6	10
No metastases at any time	43	21	49
Histopathology			
Squamous carcinoma grade 1	26	12	46
Squamous carcinoma grade ii ..	62	11	18
Squamous carcinoma grade iii	1	1	100
Adenocarcinoma	5	2	40
Spindle cell carcinoma	1	0	0
Lymphoepithelioma	1	1	100
Lymphosarcoma	1	0	0
Melanoma	4	0	0
No disease at primary site on admission	4	0	0

admission. These figures might suggest that cancer of the gum is unusually malignant once it has metastasized, but when compared with other forms of intra-oral cancer (Table IV), it will be seen that the cure rates in cancer of the tongue, the tonsil, and the cheek with metastases are at about the same level, while in cancer of the floor of the mouth, the lip, and the nasopharynx with metastases, the cure rates are somewhat higher.

Histopathology. The cure rate in cases of squamous carcinoma grade I was 48 per cent in the present series, almost twice the average and about two and one-half times that of the most frequent tumor, squamous carcinoma grade II (18 per cent). The total number of adenocarcinomas is too small to be of significance, but two of the five survived. Melanoma of the oral mucous membranes is always serious and is seldom cured. All four patients of the present series succumbed to widely disseminated disease.

END RESULTS

We have been unable to find any specific figures for five-year end results in cancer of the gums which are well-attested, that is, the few published reports are not based upon consecutive, unselected cases, all histologically proved, and in most instances too large a percentage of the patients are untraced. In some reports the data are inconclusive because of the inclusion of gingival tumors with other forms of cancer, chiefly of the antrum. The closest approximation to accurate end result figures is found in the reports of Edling[5] and Gaini,[8] both of whom used radiation as the main form of treatment. In Edling's series the diagnosis was not verified histologically in one-third of the cases. He reports three of twenty-six patients (11 per cent) alive and well, but admits that in one of these the presence of cancer was not confirmed by biopsy. Gaini[8] attempts to give five-year end results in a series of fifty-three cases. His figures are rather confusing, but the lack of adequate follow-up is apparent since in all his calculations at various periods, about one-third of the patients are untraced. He reports that at the end of five years, six patients were alive and well (12 per cent). The five-year cure rates in both of these series would probably be higher if there had been accurate follow-up and a correction for those patients who died of other causes without recurrence of cancer.

The net end results in the present series of cases, all histologically proved, are given in Table V. As has been mentioned, this series is

TABLE IV

CURE RATES IN METASTASES FROM INTRA-ORAL AND PHARYNGEAL CANCER
AT THE MEMORIAL HOSPITAL

	Per Cent
Gum..........	11
Tonsil...	10
Cheek	11
Tongue ..	12
Nasopharynx	20
Floor of mouth	22
Lip	27

made up of all patients with gingival cancer who applied at the Memorial Hospital during the years 1929 to 1935, inclusive, and were able (ambulatory) and willing to return for treatment or palliation. None was excluded because of an advanced stage of the disease. Before calculating net end results, those patients were excluded who died of other causes or who were lost track of after a year's freedom from disease. In the entire group the cure rate is

TABLE V

MEMORIAL HOSPITAL FIVE-YEAR END RESULTS IN CANCER OF THE GUMS
1929 to 1935, Inclusive

This series consists of all patients with histologically proved cancer of the gums, both early and advanced, admitted during the specified period. Only those patients are excluded who, for any reason, were unable to return for treatment, palliation and observation in the out-patient department or who were lost track of within the first month after no more than one or two visits (clinic shoppers).

Total number of cases		113

Indeterminate group:		
Dead as a result of other causes and without recurrence	6	
Lost track of without recurrence	2	
Total number of indeterminate results		8

Determinate group:	
Total number minus those of indeterminate group	105

Failures:		
Dead as a result of cancer	72	
Lost track of with disease (probably dead)	5	
Living with recurrence	1	
Total number of failures in treatment		78

Successful results:	
Free from disease after five years or more	27

Five-year end results:	
Successful results divided by determinate group ($^{27}/_{105}$)	25.7%

25.7 per cent. Among the cases of carcinoma alone, excluding melanoma, the cure rate is 27 per cent.

SUMMARY

A series of 113 consecutive cases of cancer of the gums (gingivae) is analyzed from the standpoint of etiology, clinical course, treatment and end results. Treatment methods by radiation, surgery, and combinations of the two, with their attendant complications, are described in detail.

The net cure rate in the series, calculated in 105 determinate cases, is 25.7 per cent.

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